ACID PRECIPITATION IN ONTARIO STUDY

THE ECONOMICS OF ACID PRECIPITATION

A REVIEW OF SOCIO-ECONOMIC METHODS TO ASSESS ACID DEPOSITION EFFECTS

ONTARIO MINISTRY OF THE ENVIRONMENT

CORPORATE POLICY AND PLANNING BRANCH

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PREFACE

This report summarizes three studies on economic aspects of acid rain undertaken by consultants, sponsored by the Policy and Planning Branch of the Ministry of the Environment.

These studies represent the views of the consultants and are not necessarily those of the Ontario Ministry of the Environment or the Government of Ontario.

Typographical errors and several small discrepancies in the text of this report were corrected for the July 1985 and subsequent reprints.

CHAPTER 1

INTRODUCTION

This paper provides a brief discussion of the methods developed which can be used to estimate the monetary value of the biophysical effects resulting from acid deposition. The report summarizes three studies undertaken by consultants sponsored by the PPB of MOE.

There is considerable research evidence to show that acid rain is causing widespread environmental damage. For several years, physical scientists have been researching the impact of acid deposition on crops, lakes and streams, forests and buildings. Their reports indicate the disappearance of fish and other aquatic life from lakes, erosion of statues and buildings, and spotting of tree foliage. Despite the fact that our current level of scientific understanding has not yet reached the point where we can accurately link causes and effects, and thus predict the specific benefits of particular levels of abatement, we know damages are occurring and will continue with ongoing acid deposition.

But what are the economic implications of these effects, and the economic value of the benefits of abatement, as measured by a reduction in damages due to lower levels of acid deposition? For answers to these apparently simple, yet difficult to answer, questions, we turn to economic analysis.

The task of the economist is to turn the physical and data on damages and benefits into commensurate and understandable dollar values that will permit comparisons to be made with abatement costs.

The Ontario Ministry of the Environment is carrying out a comprehensive multi-year, research program intended to determine the biophysical relationships between SO_2 and NOx emissions and the deposition of acidic materials, to document the effects of these depositions on various ecosystems and to ascertain the social and economic consequences of these effects and of the programs intended to curtail or alleviate them. This is called the Acid Precipitation in Ontario Study or APIOS.

The socio-economic component of this Program has three primary objectives:

(1) Damages and Benefits

To develop methods to estimate the biophysical effects of acidic precipitation and determine their social importance and economic value.

(2) Costs of Abatement and Mitigation

To determine the costs and other economic consequences of SO_2 and NOx abatement programs and mitigative actions to protect against the adverse effects of acidification.

(3) Tools for Strategy Development and Evaluation

To develop computational procedures and methods to help specify and evaluate policies and strategies to deal with the acid rain issue.

Economics plays a pivotal role in the APIOS program since it provides the basis for policy formulation and evaluation through the determination of the costs and benefits of various options for emissions control. Although many people may believe that physical science research alone will indicate the tolerable deposition limits or thresholds for these pollutants, in fact, each receptor tends to have its own threshold, so it will be difficult to weld a concensus on an appropriate deposition objective. Others believe that analysis of the control technologies and their costs will indicate the appropriate level of emission control. In practice, a solution which combines both economics and science is required to evaluate the costs and benefits in order to determine the most appropriate allocation of resources to deal with the issue. A more detailed discussion of the rationale for the socio-economic program is presented in the APIOS publication entitled "The Economics of Acid Precipitation: Ontario's Socio-Economic Research Program" published in December 1982.

The primary purpose of this report is to present a summary of the methodologies developed by consultants retained by the Ministry of the Environment to estimate monetary values of the biophysical effects of acid rain in fulfillment of the objectives of the Damages and Benefits component. These studies focussed on the following receptors which may be affected by acid deposition: outdoor recreation and tourism, agriculture, forestry, commercial fisheries, commerical furs, selected materials and environmental amenities. The three studies are entitled:

"Value, Awareness and Attitudes Associated with Acid Precipitation Effects in Ontario - The Amenity Value Survey", by ARA Consultants Ltd.;

"The Effects of Acidic Precipitation on Recreation and Tourism in Ontario", by Currie, Coopers and Lybrand; and

"A Methodology for Estimating the Impacts of Acid Deposition in Ontario and Their Economic Value", by Victor and Burrell, Consulting Economists.

While this report is written for the reader with some general knowledge of acid rain, some of the scientific and technical terms may be unfamiliar. To assist the reader, words underlined in the text are explained in the Glossary found in Appendix A at the end of the report.

CHAPTER 2

INTRODUCTION TO ENVIRONMENTAL ECONOMICS

2.1 Background

This chapter is intended to provide the reader with a brief review of the various methods to estimate the monetary value of the effects of acid rain. For readers unfamiliar with the details of acid rain and/or economics, a brief introduction to the relevant economic concepts are presented here.

The fundamental task facing an economist in all of this is to take information on the biophysical effects of acid rain and link them to relevant human uses, activities, perceptions and preferences in order to determine the relative social significance or value of the phenomenon or its control. Thus, the results of scientific investigations about the biophysical effects and data on the resources at risk are critical inputs to the exercise. It will be shown that there are a number of important difficulties and limitations involved in estimating the quantitative effects of acid rain and values associated with them. Approaches and methods for dealing with these problems will be noted throughout the report.

2.2 Damages and Benefits of Controls

Damages are the adverse effects of waste emissions and environmental disruptions such as acid rain when they adversely affect humans directly or human activities or environmental resources that people hold to be important. Environmental damages are often borne by those who are otherwise unconnected with the sources of the polluting materials. This is the case with acid rain, where lakes in Ontario may be acidified by acid deposition which is caused by sulphur dioxide emissions from smelting activities in Sudbury and power generating stations in the U.S. Moreover, those who cause pollution effects bear none of the adverse effects associated with them, nor do they compensate those who are affected.

Benefits are the result of actions taken to reduce or eliminate pollution or to prevent environmental disruptions, and can be expressed in the following ways:

- the adverse physical effects or damages that are reduced, eliminated or prevented,
- the added uses and enjoyment that people can gain when environmental quality is improved above existing levels,
- reductions in costs and efforts to offset pollution damages.

In some instances, pollutants may produce unintended beneficial environmental effects; these too, are considered as benefits.

When identifying and measuring the benefits of environmental protection activities, it is important to link the physical effects to uses, activities, consequences and features that are important and meaningful to people. These beneficial consequences range from reductions in human diseases and deaths, to enhanced fishing quality, or the preservation of wilderness and ecosystem integrity. The maintenance of the life support systems provided by terrestrial and marine ecosystems and the preservation of unique biological forms for future generations are all examples of environmental benefits although they are difficult to quantify, even in physical terms.

Benefits of controls or improvements are thus derived from damage estimates. Current and future levels of physical damages are estimated over a period of time given a particular "pollution scenario". Similar estimates are then made under a new "pollution scenario" which incorporates control programs. The difference between the two sets of damage estimates is the benefit of the control actions.

Damages vary over time according to "pollution intensity" as measured by discharges or ambient contaminant concentrations. A number of different damage patterns are possible:

a. Some adverse effects occur only as long as the pollutant is present.

b. Some damages or effects are irreversible, even when the pollutant is eliminated.

c. Some pollutants are thought to have threshold values below which there are no effects.

d. Some contaminants are persistent and/or bioaccumulative and remain in the environment to cause damages long after the pollutant discharges have been curtailed or eliminated, such as mercury or pesticide contamination.

People respond to pollution effects by implementing defensive or mitigative actions to avoid or offset pollution damages. In this regard, people may shift the nature or the location of their activities. For example, white bean farming has moved from the western part of Ontario to the central regions to avoid damages and consequent crop losses caused by relatively high ozone concentrations in the southwestern part of the province. Also, tobacco plants and other crops, have been developed that are more resistant to the effects of ozone. Costs may be incurred as a result of these responses or defensive actions and can be considered a part of pollution damages.

Generally, only the damages occurring in the current year can be scientifically measured. Current damages are thus exceedingly important in that they serve as the basis for predicting future damages and benefits. Current damages do not, however, represent the benefits of past or present abatement actions. The benefits of past expenditures on environmental protection would be represented by the extra damages that would have occurred if the existing programs had not been implemented. The benefits of future expenditures would be

represented by the damages reduced or avoided plus any added uses or enjoyments gained.

Damages are influenced both by the nature of the pollution, and the level of pollution intensity such as contaminant concentrations or deposition loadings. A dose-response relationship is a quantitative link between measurable physical effects, such as crop damage, and pollution intensity or levels of pollutant discharges. Such relationships are sometimes called damage functions and are required to predict future physical damages (or improvements) that occur as a result of an increase (or decrease) in the measures of pollution intensity. Ideally, dose-response functions express the bio-physical effect in quantitative terms, such as the change in crop yield.

All too often, scientific studies do not yield dose-response functions or inventory data that are useful for economic analysis. This lament, among others, is discussed extensively by Adams and Crocker[1]. For example, while a valid dose-response observation may be spotting of leaves when the pH of rainfall is 4.1, the information most relevant to the economist is whether this leaf spotting affects the plant's yield, be it apples or wood. For many crops, unless there is a change in yield, there is no economic loss. Thus, the relevant dose-response function for our purposes would indicate the change in wood harvest or apple yield as a result of the pollution exposure.

2.3 Estimation Procedure

Estimation of the economic value of environmental effects requires an understanding of the sequence of relationships among the many components. The following procedure defines the tasks and the information required to assess the physical and economic consequences of environmental effects.

a. Identify the biophysical nature of the pollution phenomenon in question in terms of sources, pollution intensity and the adverse and beneficial effects relevant to people.

b. Define relevant pollution scenarios over time.

c. Identify relevant biophysical receptor categories or species and develop quantitative estimates of the populations and resources that are exposed and at risk.

d. Determine dose-response relationships which quantitatively relate the measurable effects to relevant pollutant discharges or ambient contaminant concentrations.

e. Define a computational procedure with which to predict the expected biophysical effects, adverse and beneficial, that are likely to result from each pollution scenario over a specified planning period (e.g., 10 to 20 years).

f. Predict or determine the relevant human responses to the expected or perceived biophysical effects associated with each pollution scenario. These human responses include changes in the behaviour, activities, defensive actions, perceptions and satisfaction or enjoyment.

g. Determine appropriate monetary values to be applied to the various biophysical effects and human responses expected for each pollution (or control) scenario.

This procedure has been employed with various elaborations, exceptions and qualifications by the consultants in their respective studies. Moreover, numerous methodological problems and data deficiencies have been identified which indicate where future work should be directed.

2.4 Biophysical Information Requirements

Acidic compounds are deposited as rain and snow, called wet deposition, and as dry particulate materials. Acidic deposition is one aspect of the Long Range Transport of Air Pollution (LRTAP) phenomenon in which pollutants are chemically transformed in the atmosphere and transported many hundreds of kilometers via weather systems. Other polluting compounds, notably ozone, are associated with the LRTAP phenomenon.

Acidic deposition can vary over time and location. Therefore, data, estimates or assumptions about the current levels of deposition (wet and/or dry) at relevant locations, and whether these deposition rates will remain constant, increase or decrease over time, must be specified in order to develop pollution scenarios.

The relevant indicator of "pollution intensity" is the acidic deposition loading in wet or dry form. Acid deposition data currently being collected, however, are limited to the wet form because reliable techniques to measure dry deposition have yet to be developed. These loadings are measured as the annual deposition in kilograms per square metre ($kg/m^2.yr$) or in milliequivalents per square metre year ($meq/m^2.yr$). Some proportion of these loadings are considered to be from natural sources or background levels. Ideally, one must determine which proportion of these loadings are derived from man-made or "anthropogenic" sources and are therefore amenable to control.

Dose-response relationships of the biophysical effect for acidic deposition measures and each receptor category must also be established. Changes in the yield of a particular crop at different acid deposition loading scenarios are an example of the types of dose-response relationships required in the current investigation. The nature of the dose-response relationship varies from receptor to receptor. For example, acid deposition affects tree yield through direct impingement on foliage as well as through interactions in the soil. Some of these interactions may stimulate tree growth, while others may retard it. The result is a series of quantitative relationships that produce a net change in yield. Empirical analysis is required before we can say if the net effects result in an increase or decrease in yield. On the other hand, acidic deposition loadings

invariably act directly and adversely on buildings and materials to corrode them.

A dose-response relationship with fish is confounded in several ways. First, the linkages between acidic deposition and changes in fish yield have several intermediate interactions. Acid deposition acidifies surface waters which in turn releases materials, generally metals, into solution which are toxic to fish and other aquatic organisms including zoo-plankton and aquatic plants. Fish population declines may thus result over a period of years through reproductive failure or in one season due to fish kills caused by "acid shocks" of pH depression events associated with spring melts and runoff of acidified snow.

Quantitative estimates of the biophysical effects expected each year are made by relating the pollution scenario measures to the dose-response functions, and extrapolating the results to the total amount of the receptor category at risk. The actual computational procedures or models used will vary from one receptor category to another as explained in more detail in the text.

Finally, it is important to separate the tasks of estimating biophysical effects from the job of assigning values to them. Even without explicit value information, knowledge of the relevant biophysical effects and the uncertainties associated with them will permit the reader to make explicit trade-offs, if necessary, among the biophysical consequences and their incidence. Display of the biophysical estimates will also permit readers to apply their own weighting scheme to indicate relative importance if they do not agree with those indicated by the application of monetary values.

2.5 Determination of the Monetary Value of Damages and Benefits

In order to compare the various types of damages resulting from acid rain, or the benefits of its reduction, these effects must be expressed in comparable units. Effects must also be weighted in some manner in order to indicate their relative social or economic importance. Dollars serve these purposes particularly well since they are a standard unit of account and value in the economy and they are well understood by most people. In addition, economic values incorporate, to a varying degree, the preferences and judgements of a wide range of individuals in society.

Two broad types of monetary value measures are used in economic analyses. First, there are values which represent changes in economic welfare. These values indicate whether an individual or society is better or worse off as a result of an effect or an action. The second measure represents changes in economic activity, including employment. Economic welfare, and not economic activity, measures are the appropriate values to be used in cost-benefit assessments.[2]

With certain limitations, monetary values can be applied to the public benefits of environmental protection activities for the purposes of evaluation and decision-making. In theory, the appropriate measure of the monetary value of any consequence, effect, good or service, man-made or natural, depends on whether people perceive a gain or a

loss. Where people gain something, such as better water quality for swimming or the protection or preservation of a unique natural feature, the appropriate monetary value is the amount they are willing to pay for the benefit. However, if people affected lose something or perceive a damage, tangible or intangible, the appropriate monetary value measure is the amount they are willing to accept in compensation and still feel as well off as before. These values are called Willingness to Pay (WTP) and Compensation Required (CR) respectively. For most of the benefits of environmental protection activities, Willingness to Pay is the appropriate value measure.

Economic welfare consists of two component values, especially when they concern environmental effects and certain environmental resources. The first, financial values are the monetary value of effects, goods or resources which are associated with markets and market prices. There are two basic measures of financial values. Where producers' costs and/or revenues are affected, the change in profits to firms measures welfare change. Profits are also called producer surplus by economists. The equivalent monetary measure of welfare for consumers or users of goods and services is called consumer surplus. This is the amount people would be willing to pay for something over and above the price or cost they actually have to pay.

Amenity values are the second component of economic welfare. These are valuations that people have for resources and attributes which, for various reasons, are not reflected in market prices. For example, people may have to pay only $5.00 per year for a fishing license. However, many people would be willing to pay much more than that amount to preserve fish for their future use (option value); for use by their progeny (legacy value) or because the individuals involved believe that natural features and resources have an intrinsic right to exist (existence value). Thus, while financial values generally reflect the value of a good to users, amenity values encompass the valuations expressed by potential users and by non-users of environmental resources.

Thus, willingness to pay as represented by the sum of the financial and amenity values, is the appropriate "value" of a good, an effect or a resource to society that we seek to estimate.

Economists have developed a body of theory and various empirical methods to estimate, in monetary terms, the WTP values of environmental effects and environmental resources. In many instances, products of processes that are affected are bought and sold in traditional markets, and hence can be valued using market prices. In these instances, market valuation methods are employed to determine value. Market prices reflect the amount people are willing to pay for the goods and services that are affected by pollution and its control . The monetary value of these effects can, therefore, be estimated by multiplying the change in quantities of products or inputs that result from the environmental effect by their appropriate market prices. The increase in economic welfare is represented by these revenues, less any associated costs, or, the profits from the output.

For some effects or activities affected by pollution such as recreational fishing or human health, the relevant goods or services are

not bought and sold in markets. These activities are, however, associated with marketed goods and services. In these situations, imputed market methods have been developed to estimate appropriate monetary values.

Finally, for some products, there are not even surrogate markets which can be used to estimate monetary values. In these cases, the approach is to ask people directly what they are willing to pay (or require in compensation) in the context of an hypothetical or contingent market for the relevant environmental effect.

Within these 3 broad categories, there are specific empirical methods used to estimate values. Several are briefly discussed in this Section, particularly those most relevant to the effects of acid deposition which have been used in the Ministry's studies.

Market Valuation Methods

Two basic market approaches are Net Factor Income and Perfect Substitutes, which measure the change in the producer's income and profits.

The Net Factor Income approach takes the change in output (e.g. crop yield, forest harvest) due to the environmental change and multiplies it by the unit price as determined through market transactions. This revenue change or the product of quantity multiplied by price, must be reduced by any change in relevant costs of the affected products. In some instances, environmental effects may reduce yields or harvests by a large enough amount to push up prices. In these circumstances, the old market prices would undervalue the affected resource, and the new market price should be used.

The Net Factor Income approach is the appropriate method to use when the products affected are bought and sold in markets. These include agricultural crops, forest products, commercial fisheries and fur yields and buildings and structures. The study by Victor and Burrell presented in Chapter 5, uses the Net Factor Income approach to develop a framework for the monetary valuation of agricultural, forestry and commercial fish and fur losses resulting from acid deposition in Ontario.

The Perfect Substitutes approach measures value based on the change in inputs to produce a given product. For example, as acid deposition decreases the pH of surface or groundwater which is used for human consumption, lime is added to raise the pH to an acceptable level. The value of the damages is thus measured in part by the cost of the lime.

If market prices are changed as a result of environmental effects, then the gain or loss to users or consumers can be determined by estimating a statistical demand function by statistical and econometric methods. The gain or loss of consumer's surplus can be estimated from the demand function. Ordinary consumer's surplus is the maximum amount people are willing to pay over and above what they actually have to pay in market prices.

Imputed Market Approaches

Where markets for specific products which are affected by the change in the environment do not exist or seriously understate the true WTP value to society, an imputed market approach can be used to infer their value. These techniques include the "Travel Cost" method for recreation and the Property Value, Hedonic (attribute) Price and the Value of Human Capital methods for other effects.

Various modifications and refinements of the travel cost method are used to estimate the WTP value (e.g. consumer surplus) associated with the use of outdoor recreation sites. This method seeks to establish a relationship between expenditures on travel to and the use of, recreational sites and specific environmental quality characteristics. Expenditures themselves do not represent the consumers' WTP valuation of the site or of the environmental changes that are being examined. However, expenditure data are used to derive willingness to pay schedules or demand functions for different levels or quantities ("user days" or numbers of users per year) of site use under specific environmental quality conditions.

The difference between the average WTP to use polluted sites and the WTP to use non-polluted sites (that are similar in all other respects) is the WTP value of the higher environmental quality. There are many difficulties associated with the application of this approach, especially when many different sites are considered. However, a variation of this method to assess acid rain effects is being tested by the Federal Department of Fisheries and Oceans.[3]

Estimates of economic activity changes that may be associated with environmental quality changes are useful for assessing economic impacts and distributional implications. Environmental improvements or declines can, in some instances, be linked to expenditures on certain goods, services or activities. Thus, acid rain could very well result in changes in patterns of recreational activities which, in turn, can result in changes in associated expenditures within different regions. The study on tourism and outdoor recreation in Chapter 4 examines the possible implications of acid deposition on related economic activity throughout Ontario.

The three other methods have not been applied in this phase of the work, but are briefly presented below.

The Property Value method is based on the assumption that environmental quality is a factor which positively or negatively affects the value of a property, as determined by the real estate market. Essentially, the value of environmental attributes are determined by statistical comparison of certain properties with other similar ones not affected. The difference in value after adjustments, represents the value ascribed to environmental quality. In the case of acid deposition, the change in environmental quality may be difficult to specify and thus difficult to segregate from other factors influencing the value of property.

While, as discussed in Chapter 4, some attempt was made to examine property values in Ontario's "cottage country", this was done

on a case study or anecdotal basis rather than using this specific technique.

The Hedonic (or attribute) Price method is based on the notion that an individual's valuation is dependent on various attributes, one of which is environmental quality. Expenditures on travel or property are seen as a direct reflection of an individual's preference for environmental quality. This is separated from other attributes to estimate demand functions for environmental quality.

The Value of Human Capital method is used to estimate the financial value of morbidity (sickness) and mortality (deaths) attributed to pollution. The extra expenditures on health care due to pollution phenomenon are estimated. Wages or value of output that would be lost by people who get sick or die prematurely are added to health care costs to estimate the total financial value associated with these effects.

The valuation of human life and health has long been a focus of debate but it is generally agreed that health care costs or lost wages are an incomplete estimate and a serious understatement of the monetary value of these effects. Economists argue that increases in longevity or reductions in the probability of sickness or death should be valued according to what people are willing to pay to achieve them. Moreover, increases in the chance of death or illness due to environmental quality changes should be valued by what people require in compensation to endure these risks without sensing a loss of well-being or welfare.

Given the nature of acid deposition, basic research to define and quantify health effects is required before economic techniques can be applied to estimate any monetary values.

Contingent Market Approaches

Surveys are the primary means to determine values when no actual or surrogate markets exist. Items for which no market exists are often public goods, used by society, but not provided through market processes. These include overall environmental quality, visibility and historical artifacts and buildings. These amenities can have value both to those who use them directly as well as those who do not.

Under these circumstances, the use of a hypothetical or contingent market constructed specifically for the purposes of the analysis is required. A survey or interview procedure is employed to elicit responses to the simulated market situation to reveal the value people place on the environmental qualities or resources affected by acid rain and the services they provide. The valuations are expressed as WTP or CR. Contingent market surveys may be implemented in two basic ways. First, a technique known as the bidding game is often applied, whereby respondents are prompted, through an iterative process, to specify their maximum willingness to pay or minimum compensation required values for the environmental good in question. This approach is referred to as the Contingent Valuation method.

A second approach is that of contingent rank-ordering. The respondent is presented with a number of sites (e.g. recreational) with different attributes and option prices, and is asked to indicate his

preferences by ranking them. A statistical procedure is then applied to estimate willingness to pay.

The contingent valuation or bidding approach is preferred to that of rank ordering since it has the ability to elicit dollar values directly and can be applied to a variety of specific environmental products including visibility, ecosystem diversity, and environmental legacy. It can also be used to determine values for both users and non-users. This latter group, while they do not use Ontario's cottage country environment directly, may be willing to pay something in order to use it at a later date, (option value), or leave a productive and clean environment to their children (legacy value).

Figure 2.1 presents a summary of these economic values, the methods to obtain empirical measures and the kinds of estimates generated by each Study to help orient the reader.

2.6 Uncertainty

In many pollution situations, the cause and effect relationships between pollutants and effects are uncertain. In other cases, direct damages in specific areas or to specific populations are suspected but cannot easily be detected. In such situations, changes in the risk of the adverse effects would be the relevant measure. Risk is a statement of the probability that a particular effect will occur under different circumstances .

Uncertainty pervades the acid deposition problem. It reflects the inherent difficulty in identifying, measuring and predicting causal relationships when the range of potential impacts is very large. At the time the APIOS socio-economic work program was initiated, many of the effects were in the early stages of scientific research. A great deal of continued effort will be required to identify and quantify the range of acid rain effects. As such, this places certain limitations on the ability of economists to develop an estimate of the monetary value of effects endured to date, the potential value if acid deposition continues, and the benefits to be derived from its reduction, elimination or mitigation.

Due to the limitations imposed by these uncertainties, it is worth elaborating on their causes in order that readers will understand the constraints on the analyses which follow. In the case of acid rain, uncertainty arises from the following situations and sources:

a. uncertainty about the relationship between emissions and deposition used to define future scenarios;

b. lack of data about the size of the resources at risk. For example, this includes information on specific tree species in particular soil conditions since the scientific research is generally specie-specific;

c. information on the range of acid rain effects, such as health;

d. the potential synergistic effects of other pollutants;

e. the nature and shape of the dose-response relationship to develop quantitative estimates of the effects;

f. the difficulty of estimating appropriate monetary values for important resources and attributes affected by acid rain; and

g. lack of information about human responses to these effects, e.g., will anglers fish elsewhere or take up other activities?

Each of these factors have affected, to a greater or lesser degree, the analyses presented in subsequent chapters. It is not the intention to elaborate fully on methods of dealing with uncertainties and the limitations they impose. Rather, in each of the methodological approaches, relevant approaches to overcome them are noted. In addition, these have given shape to the conclusions and direction for further work, which are presented in Chapter 6.

Figure 2.1

SUMMARY OF ECONOMIC VALUES, EMPIRICAL MEASURES AND METHODS EMPLOYED IN MOE STUDIES

Economic Value	Theoretical Measures	Empirical Measure/Method/ Data Source	MOE STUDIES (Results)
Economic Activity	The total amount of money passing through a community or region during a period of time.	Direct Expenditures: -Statistics Canada) -Other Sources) (Secondary Data) -Surveys (Primary Data) Indirect Expenditures: -Input Output Models -Regional Multipliers ..... Business Sales and Revenues:	Tourism Study (Direct Expenditures) Tourism Study (Indirect Expenditures) Financial Value Study (Revenue for agriculture, commercial fisheries, commercial furs and selected materials sectors)
	The total number of people employed in a community or region during a period of time.	Employment Statistics: -Statistics Canada -Provincial Governments Unemployment Statistics: Wage Rate: -$ expenditure or sales per year per job	Tourism Study (Based on $22 - 23 K per year per job)

Continued.

Figure 2.1 (Continued)

Economic Value	Theoretical Measures	Empirical Measures/Method/ Data Source	MOE Studies (Results)
Economic Welfare	Financial Values: -Producers' Profits (Change in output times market prices less change in production or O & M costs)	Net Factor Income:) Perfect Substitutes:) ..... Value of Human Capital:	Financial Value Study (Change in profits for commercial fishing and agriculture. Change in costs for forestry and materials.)
	-Ordinary Consumers' Surplus (Total willingness to pay above market price that has to be paid.)	Statistical Demand Functions: Property Value Method: Hedonic Price Method: Travel Cost Method:	
	Amenity Values: -Willingness to Pay (To gain or preserve an attribute, good, service or amenity)	Contingent Value Survey: ..... Contingent Rank Ordering:	Amenity Value Survey (Willingness to pay to preserve environmental resources threatened by acidification)
	-Compensation Required (To incur damage or loss and feel as well off as before)	Contingent Value Survey:	

FOOTNOTES TO CHAPTER 2

1 Adams, Richard A. and Thomas Crocker, "Dose-Response Information and Environmental Damage Assessment: An Economic Perspective", Journal of the Air Pollution Control Association, October 1982, pp. 1,062-1,067.

2 The reason why economic activity estimates are not normally used in cost-benefit assessments is that an increase in economic activity and employment in one region or economic sector is often accompanied by a corresponding reduction in (real or potential) economic activity and employment in another sector or region. The two changes thus cancel each other out for society as a whole. This, of course, does not mean that regional or sectoral impacts should be ignored.

3 Personal Communications from Dr. T. Wise, Manager, Economic Research, Department of Fisheries and Oceans, Ottawa.

CHAPTER 3

THE AMENITY VALUE SURVEY - VALUATION OF INTANGIBLES AND AMENITIES

3.1 Introduction

Many attributes of the environment or of environmental resources which people use and enjoy are intangible and cannot be bought and sold in markets. These resources are also of value to people who do not use them but desire to maintain such features for future use, for the use and enjoyment of their children or because they believe that the environment and its components have an intrinsic value whether they are used directly or not. While these amenities are not bought and sold in markets, people do have preferences and values for them. The problem is to find ways to get people to accurately express these values.

Monetary valuation of intangible attributes is more common than one might expect. For example, people are willing to pay measurable amounts of money to obtain such intangible features as "brand names", over and above what they would have to pay for substitutes without them. Courts and governments routinely award financial compensation to individuals for intangible losses arising from actions such as criminal assaults, accidents and breach of contract.

There is substantial evidence that non-users, as well as users, place a value on the preservation and enhancement of environmental resources which yield intangible benefits and enjoyment. The passage, administration and enforcement of environmental protection legislation is one indication of society's willingness to pay, through the allocation of government resources, to protect and improve these resources.

Where markets are not available to estimate monetary values, an appropriate recourse is to ask people directly what they would be willing to pay (WTP) to gain the amenities associated with environmental improvements or what they would require in monetary compensation (CR) to sustain losses. This is accomplished through the use of questionnaires and surveys.

The use of surveys to elicit values for environmental amenities is still in the process of development. However, economists can draw upon a broad background of survey techniques in applying this method to the valuation of environmental resources. In developing the Amenity Value Survey, the Ministry of the Environment used a two-phase approach. The first phase was to review the literature on willingness to pay methodologies and results in order to design a questionnaire which would be appropriate to survey individuals' responses to acidification of the environment. The second step was to carry out a questionnaire survey of approximately 900 individuals to determine, among other things, the value they place on environmental amenities affected by acid rain.

The literature review is contained in a study entitled "Amenity Values: A Critical Review of the Survey Methods and Applications"

prepared by Myra Schiff Consultants Ltd.[1] The survey and its results are described in the study, "Value, Awareness and Attitudes Associated with Acid Precipitation Effects in Ontario - The Amenity Value Survey" by ARA Consultants Ltd.[2]

This Chapter summarizes the work contained in these two studies. The survey methods intended to obtain WTP or CR values for environmental quality changes are reviewed highlighting certain weaknesses, or biases, thought to be associated with these approaches, which can diminish the reliability or accuracy of their results. The ways in which the questionnaire was designed and implemented to address these issues is discussed. The development of a survey questionnaire intended to obtain WTP estimates, as well as other information about individuals' preferences and attitudes concerning the resources threatened in Ontario by acidification is described. Finally, some comments on the implementation of the questionnaire and its possible future uses are also noted.

3.2 Survey Instrument Design

The specific objectives of the Amenity Value Survey were as follows:

a. to determine the monetary value which people place on changes in the quality of environmental amenities caused by acid deposition;

b. to determine the socio-economic factors which might account for the variation in monetary values obtained;

c. to determine the level of awareness regarding acid deposition as well as individual attitudes and beliefs with respect to pollution and acidic deposition;

d. to determine the likely behaviours and substitution activities in response to environmental pollution and acid deposition.

The process used to develop the survey questionnaire involved an extensive, three-phase pre-testing program. Of particular interest are the methods used to offset the various sources of bias noted in section 3. Several approaches were devised and tested to provide subjects with sufficient information about the biophysical and environmental changes or effects of acid precipitation and enable them to provide meaningful WTP and other responses.

To define the hypothetical situation, an approach suggested by Mitchell[3] was adopted. This involved the development of an "Environmental Quality Ladder" which describes in both pictures and words the characteristics of a lake at various stages of acidification. No time frame for arriving at these different acidification states was specified. This device, which is shown in Figure 3.1, was also used to orient respondents to the current, overall environmental quality found in the province. Subjects were then asked how much they were willing to pay to avoid going from the current, overall quality to successively acidified states.

A card containing estimates of taxes and prices paid by different income groups for specific public goods and services was presented to each respondent. These Taxes and Prices Scales, shown in Figure 3.2, were also suggested by Mitchell. This device enables the respondents to pick his own initial value without any specific suggestion from the interviewer which could bias the responses. It also specified the payment mechanism for the respondent.

Two particularly important questionnaire design features emerged from the pre-testing. First, it was found that questions about what people would be willing to accept in compensation (CR) for existing or future environmental damages evoked considerable repondent hostility and many refusals to answer. It was clear that respondents did not regard themselves as having an explicit or intrinsic right to the environmental resources to which the survey referred. Similar respondent hostility to CR questions, and a high refusal rate (50%), were also noted by Randall et al.[4]

Willig[5] and other economists have argued that differences among the theoretically appropriate measures of WTP and CR are expected to be "small and almost trivial for most realistic cases".[6] However, where the survey method has been applied to obtain measures of both WTP and CR, wide differences have been found.[7]

Knetsch[8] argues that compensation required will invariably be larger than willingness to pay because:

a. there are no income constraints operating with respect to compensation;

b. people regard losses more seriously than gains, particularly at the margin.

In any event, for questionnaire design, it is critical to determine whether WTP or CR is most appropriate to the problem at hand. If the object is to determine the value of losses or damages to resources or features in which people believe they have an interest or a right, compensation required is the appropriate value and questions should be designed accordingly. On the other hand, if the issues concern the preservation or gain of environmental amenities, resources or opportunities which people enjoy, questionnaires should ask what people are willing to pay.

With respect to acid rain, the key issue is the prevention of future deterioration and damage. Consequently, willingness to pay is the appropriate valuation measure in the context of this survey and the compensation questions were dropped.

The second design feature that was examined during pre-testing was to identify acid rain as the explicit cause of the problem. There was concern that this might bias the responses. During the third pre-test of 65 respondents, half were told that the survey specifically concerned acid rain while the other half were told only that the environmental effects described had been caused by "pollution" in general or by some other "natural" causes. Analyses of the results

Figure 3.1

ENVIRONMENTAL QUALITY LADDER

10 — "Unpolluted" environment - all fish, wildlife and plants healthy and abundant. Restoration of some fish species such as aurora trout and salmon to waters where they used to be naturally, but declined.

9 — Environment with a wide variety of wildlife, plants, etc. In some parts of the Province the best sports fish no longer exist, such as walleye.

8 — Ontario Environmental Quality Level - Good fishermen would catch 10 fish in 2 days. Forests, wildflowers and wildlife healthy and in abundance.

7 — Generally healthy and varied wildlife and vegetation. Some decline in sports fish numbers and types (bass). Average fishermen would catch 7 fish in 2 days.

6 — Wildlife and vegetation still relatively healthy and varied. Aquatic life not as abundant - fewer frogs, less waterplants and loss of some sports fish such as trout. Fishermen would catch 3 fish in 2 days.

5 — Wildlife and vegetation declining - fewer otters, ducks and loons. Very few fish types - yellow perch, chub and suckers left in lake.

4 — Only one kind of fish - yellow perch left. Frogs are rare and the small vegetation growth around the lake is rare. Water seems clear, and there are very few water birds (ducks, loons) and fish-eating wildlife (raccoons, otters).

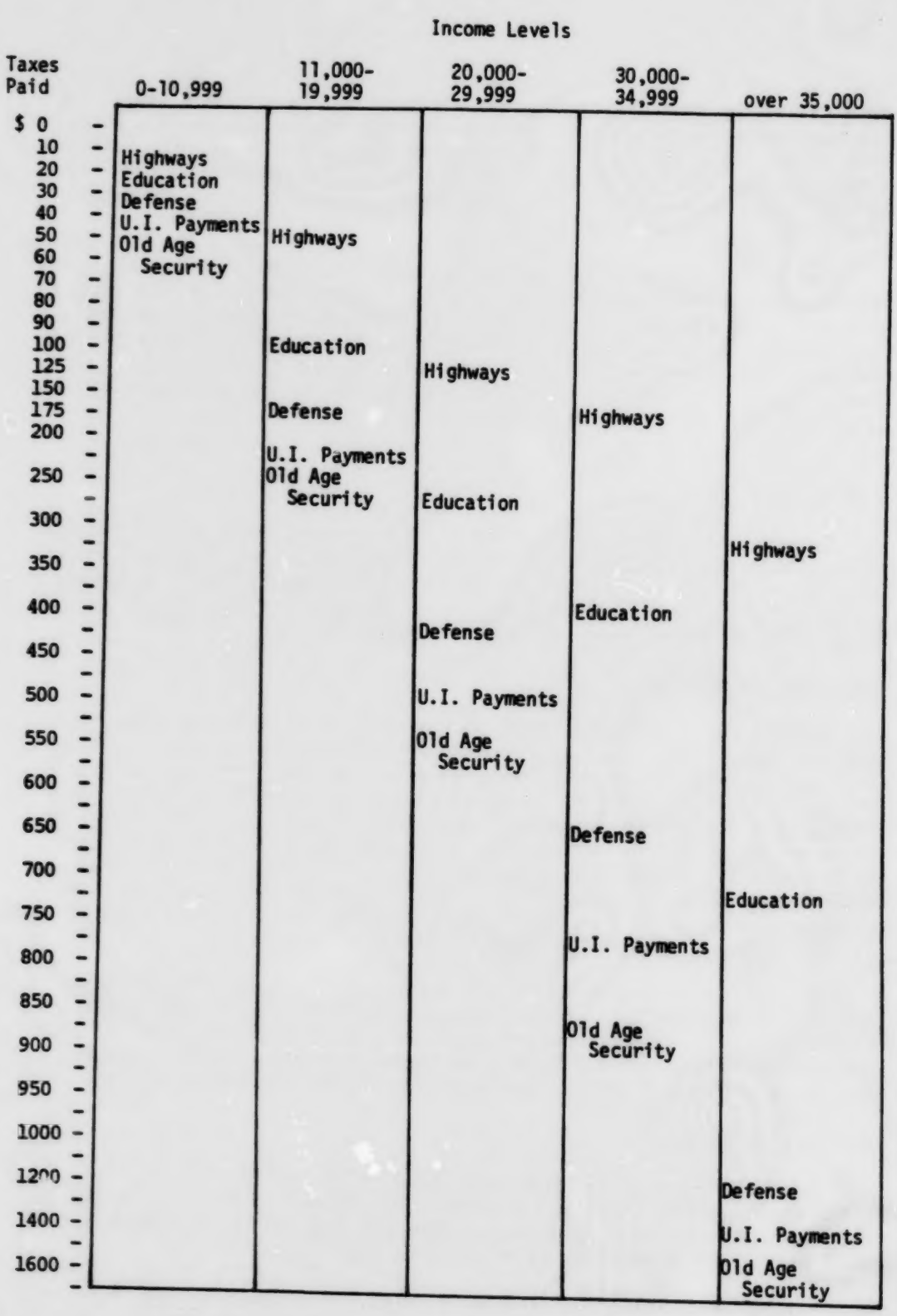
3 — No fish left in the lake and wildlife which depend on fish for food are gone. Water plants except for moss have disappeared and the lake water is crystal clear except for a green film in the water.

2 — The lake water is very clear, but there is virtually no sign of fish-eating wildlife in the form of ducks or small animals, a very few birds. The trees and shrubs seem thin and the leaves of some are spotted with brown.

1 — Polluted environment - fish, wildlife, plants seem less healthy and less abundant. Some species no longer exist in the Province.

0

Figure 3.2


Income Levels
Taxes Paid
0-10,999
11,000-19,999
20,000-29,999
30,000-34,999
over 35,000
$ 0
10
20
30
40
50
60
70
80
90
100
125
150
175
200
250
300
350
400
450
500
550
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Old Age Security
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Old Age Security
Education
Education
Defense
Defense
U.I. Payments
Old Age Security
Highways
Education
U.I. Payments
Old Age Security
Defense
U.I. Payments
Old Age Security

from this pre-test revealed that people who were told that the questionnaire concerned acid rain gave statistically the same answers and value estimates as those who were not given this information. Consequently, all respondents in the final survey were informed, before being interviewed, that the study was concerned specifically with acid rain and its effects.

Another problem that can affect the reliability of answers to questionnaires is "respondent fatigue". If the questionnaire is long or tedious, respondents may give frivolous answers to speed things up or will terminate the interview prematurely. In order to maintain the attention and interest of the respondents for the Amenity Value Survey, the respondent was handed sections of the questionnaire to fill in at different points in the interview.

3.3 Sources of Bias

Potential problems with the survey method may systematically distort the results obtained through this approach. Collectively, these are called sources of bias. They have been identified as strategic behaviour, starting point bias, information bias and payment mechanism bias. Each of these topics are discussed briefly.

Strategic Behaviour

Economists have been most concerned about strategic behaviour because people may have an incentive to overstate or understate their true willingness to pay. If people believe that they will not really pay anything on the basis of their answers, they may overstate their willingness to pay in the hopes that the program or project will be implemented. On the other hand, if people believe that they will have to incur a tax or a price increase, then they may understate their willingness to pay in hopes that they will avoid any cost increases. Furthermore, people may register a zero or a very high bid as a statement for or against the issue in question.

Schiff[9] notes that Bohm[10], Brookshire et al.[11], and Rowe et al.[12] conducted studies in which they specifically tested for strategic behaviour. These researchers could not find any evidence of such behaviour in their work. Based on these and other studies, strategic bias does not appear to be a problem in properly structured surveys.

Starting Point Bias

Another concern is that the final WTP or CR figure may be influenced by the value of the initial bid offered to the respondent to help him get started. The higher the starting point, the higher the final bid. This is referred to as starting point bias.

Randall and Stoll[13] as well as Randall, Gruenewald et al.[14] tested for this source of bias, and reported no evidence of "starting point bias" in their results. Thayer[15], who designed his study to specifically detect such bias, could find none either. Mitchell[16] and Berry[17] suggest that "starting point bias" can be avoided by providing

respondents with information about the annual expenditures, by income category, of an individual for police, fire protection, education, defence and other public programs. Subjects use this information to formulate their own bids without a prompt from the interviewer. Consequently, this potential source of bias can be eliminated through questionnaire design.

Information Bias

Some authorities reason that responses will be biased if some people have more information about the question being asked than do others. The questionnaire itself may provide respondents with certain information about the feature to be valued that the general public does not possess and so will affect the WTP values of the people being interviewed. Thayer[18] also designed his study to test the effect of having different respondent groups possess different types of information. He found no statistically significant differences in their WTP values.

Schiff[19] suggests that there really is no such thing as "information bias". People formulate their valuations on the basis of information available to them at any particular time. If all respondents are provided with a common information set concerning the hypothetical situation under study then the valuations that are given are as accurate and valid as can be expected. However, it would still be prudent to ensure that all respondents have a similar information set.

Payment Mechanisms

Various researchers have found that specifying how the WTP would be paid helps to make the hypothetical markets and questions more realistic. Moreover, responses may be influenced by the payment mechanism itself if repondents have strong feelings about their local utility or about taxes. Payment mechanisms used in various studies include electric bills, sales taxes, other taxes, license fees, user fees and payments to a special environmental fund. Schiff[20] suggests that a payment mechanism be specified in surveys to which people can relate, such as utility bills or taxes, but that tests be made to determine if these mechanisms affect responses.

3.4 Respondent Sampling Procedure

Consideration was given to obtaining a representative sample of the entire Ontario population. This sampling strategy was rejected in favour of a target population of people who lived in or used an area of the province that is particularly threatened by acid precipitation for the following reasons:

a. There is particular concern and interest in these regions;

b. The people who live and recreate in these regions were expected to be most knowledgeable of acidification effects and, therefore, be more willing to cooperate in the survey;

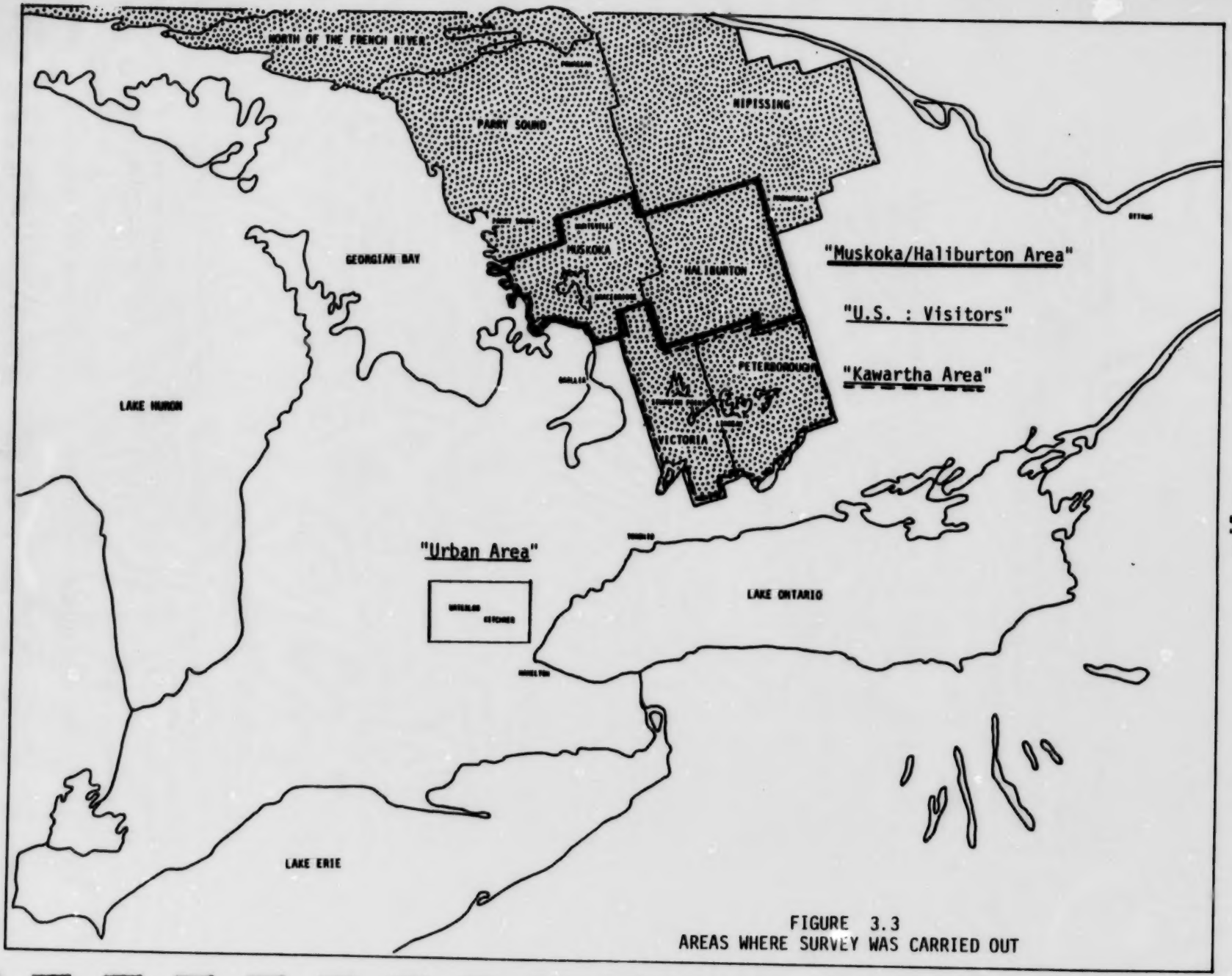

FIGURE 3.3
AREAS WHERE SURVEY WAS CARRIED OUT

c. As the study was the first survey of its kind for the Ministry, a more concentrated, easily administered study was deemed preferable to an extensive, and considerably more costly, sampling throughout the province.

A total of 900 respondents were sampled within five respondent groups from three geographical areas (pictured in Figure 3.3). The lakes in the Muskoka/Haliburton area are potentially threatened by acid precipitation. The Kawarthas is another vacation area with calcareous bedrock and lakes that are moderately sensitive to insensitive to acidification. Kitchener/Waterloo is the fourth largest urban area in Ontario. U.S. residents visiting the Muskoka-Kawartha areas were also sampled. The repondent groups and the samples taken of each are listed in Table 3.1 below.

The "Urban" (Kitchener/Waterloo) and "Cottage Country Users" (Muskoka/Haliburton, and the Kawarthas) samples necessitated two slightly different questionnaires. The differences are only in the first eight questions and concerned the respondent's accommodation in the cottage country. The cottage country questionnaire is presented in Appendix B.

3.5 Survey Results

Awareness and Attitudes

Respondents were asked whether they "strongly agreed", "agreed", "disagreed", or "strongly disagreed" with a series of statements. The pattern of responses indicates a strong concern about pollution. Pollution is seen as a major and immediate problem by most people sampled. They believe that it is a "here and now" problem. They indicated that immediate action should be taken to deal with pollution, even if it means some sacrifice of income for Ontario residents.

The respondents were also asked to agree or disagree with a series of statements which have implications for actions to be taken to deal with pollution. Over three-quarters of the respondents agreed, or strongly agreed, with the following statements:

a. protecting the environment is so important that the requirements and standards cannot be too high;

b. the Ontario government is much too soft on companies which pollute the environment; and

c. protecting the environment is so important that continuing improvements must be made regardless of cost.

In particular, 83% of the respondents either disagreed or disagreed that "we must relax environmental standards in order to achieve economic growth".

TABLE 3.1

AREAS AND TYPES OF RESPONDENTS SURVEYED

	Muskoka/Haliburton Area*	Kawartha Area	Totals
Cottage Country Users			
Cottage Country Residents	149	61	210
Cottagers	119	84	203
Occasional Visitors	130	71**	201
SUB TOTAL	398	216	614
U.S. Visitors	-	-	100
Urban Residents	-	-	206
TOTAL			920

* Includes residents, campers and cottagers near Burk's Falls, Parry Sound.

** Includes 17 campers sampled in Sturgeon Bay Provincial Campgrounds.

Source: ARA Consultants Ltd., "Value, Awareness and Attitudes Associated with Acid Precipitation Effects in Ontario - The Amenity Value Survey", 1982, p. 31-34.

The purpose of including these items in the survey was to establish the importance which people place upon the issue of pollution and its control. These results are consistent with other polls which indicate a very strong public concern about pollution and support for environmental protection.

Virtually all respondents, 97% of the total sample, had heard of acid rain, although the number with more detailed knowledge of the phenomenon was considerably lower. In total, 73% indicated that they believed acid rain is a serious problem.

Other pollution problems were also considered to be serious issues in Cottage Country such as oil and chemical waste, hazardous waste products and water pollution from sewage. Of minor concern by cottage country respondents were waste disposal, nuclear power plants and noise.

Willingness To Pay

The Environmental Quality ladder was used to elicit responses on the amounts people were willing to pay to prevent varying degrees of environmental degradation. A significant degree of deterioration of the environment is represented by the change from level 8 (defined as the prevailing situation) to level 4. To protect the environment from this degree of change, 74% of all people interviewed indicated they would pay higher prices and taxes. Moreover, 38% would be willing to pay more than $100 annually. The 26% of respondents who indicated they would pay nothing or had no answer, did so because they simply couldn't afford to pay more, or because they were not able to state a valuation at that time.

The specific amounts indicated by those willing to pay varied considerably, but were correlated with education and income. The amount of money which respondents were willing to pay to prevent deterioration in the environment amounted to, on average (i.e., median value), one-half of one per cent of their annual household incomes. Interestingly, there was little variation among the three major subgroups in the sample-urban residents, Cottage Country residents, and U.S.A. visitors.

There were some variations in willingess to pay among users and non-users of the environmental resources of Ontario's cottage country. Those respondents who fish and swim in cottage country are willing to pay more money to protect the environment than those who did not engage in these activities. Among those individuals who were interviewed in the urban centre, 87% of those who do swim in cottage country were willing to pay something, but 70% of those who do not swim in cottage country were also willing to pay something. In other words, many people are willing to pay something to preserve cottage country, even though they may not personally make use of it. This is called an "existence value".

Behavioural Responses

One important information gap identified in the Tourism and Recreation study discussed in Chapter 4, is the response of anglers to the decline in fish productivity. The results of the Amenity Value Survey provide some preliminary information about this question.

Respondents were asked what they might do if they could no longer fish or swim in cottage country. The objective was to determine whether they would continue to come to the cottage country, but engage in different activities, or whether they would simply stop coming to cottage country, so that they could pursue their favourite activity in a less polluted environment.

All respondents were asked whether or not they usually went swimming in cottage country. Those who indicated that they were swimmers were asked what they would do if they found that they could no longer go swimming in their usual lake or river in cottage country. Sixty per cent of the U.S.A. visitors and 45% of the Urban Residents indicated that they would no longer come to cottage country. On the other hand, only 26% of the Cottage Country Users subgroup said that they would no longer come to cottage country. When asked how much further they would be prepared to travel than they now do in order to find a lake in which they could swim, only 13% of all respondents were willing to drive more than 100 miles to find another place to swim.

The respondents were also asked if they ever fished in cottage country. Those who said that they did fish were asked what they would do if they could no longer fish in their usual place in cottage country. Many of the Urban Residents (37%) and U.S.A Visitors (54%) indicated that they would no longer come to cottage country. However, only 13% of the Cottage Country Users indicated that they would no longer come to cottage country if they could no longer fish. As with swimming, Cottage Country Users are more likely to remain in cottage country even if fishing was poor. This is because many of the respondents in this subgroup are either residents in the area or they owned vacation cottages.

People were asked how much further they would be prepared to travel than they do now in order to find a lake where they could fish. The U.S.A. Visitors (49%) and Urban Residents (39%) would be prepared to travel an additional hundred miles or more to find a fishing spot. However, only about one-quarter of the Cottage Country Users would be prepared to drive 100 miles or further.

Where the respondents could not swim, the most frequently mentioned substitute activity was taking scenic walks. Other substitute activities included motor boating, canoeing, and fishing. Camping was an especially popular substitute activity among U.S.A. Visitors and Urban Residents.

If the respondents were unable to fish in their usual place, the majority of Urban Residents (59%) and Cottage Country Users (59%) stated that they would swim instead. On the other hand, very few of the U.S.A. Visitors selected swimming as their alternate activity (6%). Instead, the most popular substitute activity selected by this latter group was motor boating (53%).

3.6 Conclusions

The extensive literature search was extremely useful to the design of the Amenity Value Survey questionnaire and pre-testing. The contingent valuation technique was shown to be a practical means of obtaining willingness to pay values. Responses indicate a strong concern for pollution and the environment, among both users and non-users of cottage country, as well as both Ontario and U.S. visitors. These attitudes are further evidenced by a positive willingness to pay among three-quarters of those surveyed. These results appear to be free of the potential biases which might distort their usefulness.

The initial questionnaires were lengthy because numerous questions were tested. Despite considerable consolidation, each interview averaged 30 minutes. Many more questions could have been asked, but these will have to wait for future surveys. Surveys taken at regular intervals can gauge and compare public attitudes and awareness of environmental issues. They can also help estimate the value of many types of environmental amenities.

FOOTNOTES TO CHAPTER 3

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18 Thayer, M., op. cit., 1981.

19 Schiff, M., op. cit., 1981, p. 29

20 Ibid., pp. 23-25

CHAPTER 4

THE EFFECTS OF ACIDIC PRECIPITATION ON RECREATION AND TOURISM IN ONTARIO

4.1 Introduction

Tourism ranks second only to transportation equipment as Ontario's largest export industry generating expenditures of over $6 billion (1981) annually.[1] Tourism also provides an important source of employment and economic activity to communities throughout Northern, Central and Eastern Ontario. Many of the outdoor recreational activities which attract visitors to Ontario, and to the resort and cottage areas in particular, are based on environmental resources that may be adversely affected by acidic deposition.

Many individual recreation activities are based on specific environmental resources. Swimming and fishing depend on high quality lakes and an abundance of fish. Other activities, and the attractiveness of the cottage country region, are dependent on the overall quality of the environment. The study described here focusses on tourism and outdoor recreation activities which are dependent on the aquatic resources because the aquatic ecosystem is most vulnerable to acidification damages.

This chapter summarizes the framework developed and the methods employed for the estimation of the potential economic activity effects of acid precipitation on water-based tourism and recreation. The study was undertaken for the Ministry by Currie, Coopers and Lybrand and is entitled "The Effects of Acidic Precipitation on Recreation and Tourism in Ontario". The specific methods and the information needed to estimate the effects of acid deposition on recreational activities and tourism are described. The effects of factors other than acid rain which influence recreational demand and tourism in Ontario are also discussed.

4.2 Links Between Acidic Precipitation and Key Recreation and Tourism Resources

The point of entry to the analysis was to (1) identify the major biophysical effects acid precipitation has on the environment and (2) the linkage between those physical effects and recreational activity. On the basis of current knowledge, the most dramatic and, by far, the best documented effects of acid deposition are through the aquatic environment. Therefore, as indicated in Table 4.1, potentially affected recreational activities are fishing, waterfowl and moose hunting, and water contact activities such as swimming and boating. Of these activities, however, a quantitative dose-response relationship could only be developed for sportfishing. For this reason, emphasis was placed on developing a computational procedure from which levels of acidification could be translated into a change in fish productivity and assumptions were made to estimate the resulting change in recreational fishing occasions. Expenditures associated with the estimated changes in fishing occasions were then estimated to determine the potential effect on regional economic activity and employment.

TABLE 4.1

AQUATIC-BASED OUTDOOR RECREATIONAL ACTIVITIES THAT ARE POTENTIALLY SUSCEPTIBLE TO ACID PRECIPITATION

Activity	Physical Effect	Implications for Recreation
Fishing	- toxicity stresses and mortality - reproductive failures - food chain	- reduced quantity and quality of fishing
Swimming Water Skiing Scuba Diving	- no known health effects - initially clearer water - subsequently troublesome aquatic vegetation	- initially enhanced - ultimately degraded
Boating	- no known effect	
Waterfowl Hunting	- food chain	- possible reduction in available breeding areas
Moose Hunting	- food chain	- may reduce area of suitable habitat

4.3 Aquatic Recreation And Tourism Activities In Ontario

To provide a context from which lake acidification effects can be viewed, an estimate of the level and economic importance of affected recreation and tourism activities within Ontario is necessary. Based in part on the sensitivity to acid deposition and in part on available tourism information, the province was partitioned into four major regions, as shown in Figure 4.1. These areas, Eastern, Northeastern, Northwest, and the Parry Sound-Muskoka-Haliburton regions, are all considered to be acid-sensitive because the underlying geology has a limited ability to buffer or neutralize acidic deposition as it enters the lake and water systems. The remaining regions of the province are adjacent to the Great Lakes which, to date, do not appear to be sensitive to the effects of acid rain.

For each of these regions a profile of aquatic-based recreation and tourism activity was developed. This profile consisted of estimates of the number of "home-based" day trip occasions and overnight trips during 1980. The estimates are based on the Ontario Recreation Survey carried out in 1972-73.[2] The distinction between day and overnight trips is important since the economic significance of these activities was estimated on the basis of expenditures made by these tourists. Overnight trips involve a higher level of expenditure on items such as accommodation and food than day trips. The profiles include participation rates for the following recreational activities: swimming, boating, sportfishing, water-skiing, scuba diving and waterfowl hunting. Home-based and day-trip categories were further divided into resident of Ontario and non-resident activity.

In 1976, tourists made 102,271,000 "person trips" within Ontario[3]. About 70% of these trips were made by Ontario residents, 20% came from the U.S. and the remainder travelled from other Canadian Provinces.

A user occasion is a measure of recreational activity in which any part of a day is spent participating in a particular activity, such as swimming. Based on data from the Ontario Recreational Survey, estimates of the number of user-occasions per year during 1980 of aquatic-based recreational activities were prepared. Day-users participated in approximately 69 million home-based user-occasions of aquatic-based recreation activities in 1980. Of this total, the study area regions account for 29 million or 42% of home-based aquatic activities. As displayed in Table 4.2, swimming is the most popular home-base day use activity. However, almost 50% of all day-use fishing occasions occur in the acid-sensitive regions of Ontario.

Out of a total 330,000 cottages in Ontario, about 217,000 or 65% are located in areas where many of the lakes and streams are threatened with acidification. Of these cottages, 84% are owned by Ontario residents. Nonresidents have more flexibility in changing their location and type of recreational activity in response to acidification of the aquatic environment, and may shift their activities to non-acidified areas outside the Province. If this were to happen, their expenditures could be lost to Ontario.

Figure 4.1

POTENTIALLY ACID-SENSITIVE ONTARIO REGIONS USED IN THE TOURISM STUDY

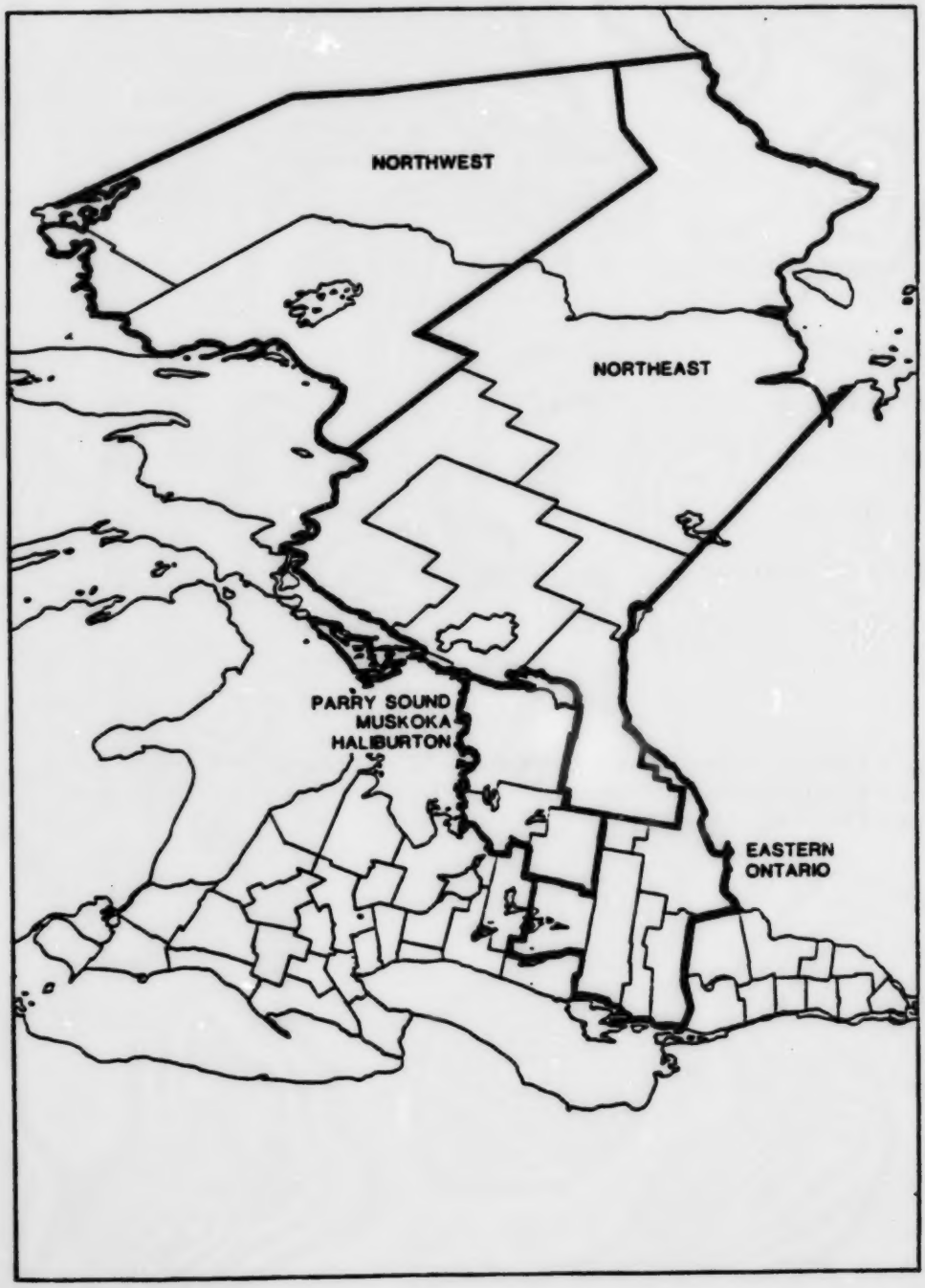


TABLE 4.2

TOTAL DAY-USE OCCASIONS AND NON-RESIDENT OVERNIGHT VISITOR OCCASIONS FOR AQUATIC-BASED RECREATION AND TOURISM IN POTENTIALLY ACID-SENSITIVE AREAS OF ONTARIO (1980)

	Day-Use Occasions (000's)	% of Total Day-Use Occasions in Ontario %	Non-Resident Overnight Occasions (000's)	% of Total Non-Resident Overnight Occasions in Ontario %
Swimming (natural environment)	11,896	37	769	33
Boating	6,947	44	1,487	30
Sportfishing	9,126	49	3,366	29
Water Skiing	890	51	166	6
Scuba Diving	54	35	18	1
Waterfowl Hunting	109	30	10	0.3
Total	29,022	42 %	5,816	99.3 %

SOURCE: Currie, Coopers and Lybrand. "The Effects of Acidic Precipitation on Recreation and Tourism in Ontario", Vol. I., February 1982, pp. 17, 18 and Exhibit 7.

4.4 The Economic Importance of Aquatic-Based Recreation And Tourism In Ontario

Most outdoor recreational activities are not bought and sold in markets. Therefore, market prices charged for fishing and swimming, if any can be found, do not accurately reflect the value of these activities in terms of what people are actually willing to pay for them. As noted in Chapter 2, WTP or CR values for recreational activities can be estimated through a survey questionnaire or by estimating demand functions by means of the travel cost method.

Changes in regional and local economic activity, including employment, are associated with environmental effects. Estimates of potential changes in regional economic activity resulting from lake acidification were made using statistics on expenditures for complementary goods and services. These estimates indicate the magnitude of potential economic impacts but should not be interpreted as "the value of recreation" or total "value of acid rain effects on sportfishing". Thus, for each of the aquatic-based activities, average levels of expenditure were calculated. Food, fuel, lodging, guide services, licences and permits are included in these expenditure estimates. Home-based or day-use activities were also estimated by activity, whereas activities associated with overnight stays were measured by type of accommodation used.

In addition to direct expenditures, estimates of indirect expenditures and employment were made. Indirect expenditures are those made by people who received the direct expenditure. They are calculated by multiplying the direct expenditures by the following regional multipliers, developed in another provincial study.[4]

Parry Sound, Muskoka and Haliburton	1.6
Acid-Sensitive Eastern Ontario	1.6
Northeastern	1.5
Northwestern	1.4

The multipliers indicate that for every $1 spent on aquatic-based tourism, a total of $1.40 to $1.60 is generated in regional economic activity. Estimates of person-years of employment were calculated from regional estimates of direct expenditures required to generate one local employment opportunity. The factor used was $23,000 per person per year.

Aquatic-based recreation activities directly and indirectly generate annual expenditures of about $900 million and $750 million respectively in Ontario. The proportion of economic activity which aquatic-based tourism contributes directly to each region of the province is shown in Table 4.3. Estimates of employment associated with these expenditures are noted in Table 4.4.

Estimates of the WTP or CR values associated with these aquatic-based activities were not undertaken by the consultant. A Contingency Value survey was already underway by another contractor and the consultant found that the requisite data were not available to estimate demand functions in the various acid-sensitive regions using the travel cost approach.

TABLE 4.3

DIRECT EXPENDITURES ON AQUATIC-BASED TOURISM AND RECREATION

	Direct Expenditures ($ Millions 1980)	% of Total
Sensitive Ontario		
Parry Sound, Muskoka and Haliburton	$ 120	13%
Acid-sensitive Eastern Ontario	135	15%
Northeastern Ontario	125	14%
Northwestern Ontario	71	8%
Total Sensitive	451	50%
Non-Sensitive Ontario	466	50%
Total Ontario	917	100%

SOURCE: Currie, Coopers and Lybrand, "The Effects of Acid Precipitation on Recreaton in Ontario", Vol. I., February 1982, p. 19.

TABLE 4.4

EMPLOYMENT OPPORTUNITIES RELATED TO AQUATIC-BASED RECREATION AND TOURISM IN ACID-SENSITIVE AREAS

	Number of Employment Opportunities	% of Total Area Labour Force
Parry Sound, Muskoka and Haliburton	5,500	16%
Acid-sensitive Eastern Ontario	5,900	3%
Northeastern Ontario	5,700	2%
Northwestern Ontario	3,200	3%

SOURCE: Currie, Coopers and Lybrand, "The Effects of Acid Precipitation on Recreaton in Ontario", Vol. I., February 1982, p. 20.

4.5 Other Factors Which Affect Recreation and Tourism in Ontario

It is recognized, of course, that acid precipitation is only one of many factors which influence current and future patterns of aquatic-based recreation. A review of these factors and influences is presented below.

Five key factors influence the **demand** for outdoor recreation activities and tourism-related services in Ontario:

a. population growth and age structure;
b. leisure time availability;
c. trends in activity participation;
d. income;
e. foreign exchange differentials.

Examination of these factors suggests that participation and expenditures associated with aquatic-based activities will grow very slowly or possibly even decline, over the next 20 years. For example, the population in Ontario and neighbouring provinces is growing very slowly and, on the whole, is getting older. Older people have typically exhibited lower participation rates for aquatic-based recreational activities. These trends are expected to accelerate beyond 2001.

Furthermore, people will not likely have substantially more leisure time in the future which can be devoted to outdoor recreational activities and overnight trips to recreational areas. It is often difficult for families with two wage earners to coordinate vacation times. Moreover, both spouses have to devote more of their spare time to sharing domestic duties.

Surveys in Ontario and elsewhere do not reveal a large, unfulfilled demand for aquatic-based recreational activities among current non-participants. Disposable income, or the money people have after paying taxes, loans, mortgages, food and shelter, is another important determinant of outdoor recreational activity. However, growth in real income (adjusted for inflation) has slowed considerably in recent years. This, coupled with substantial increases in the costs of travel as well as other goods and services complementary with tourism, suggest curtailed growth or even possible declines in future participation rates.

Over the past two years, the value of the Canadian dollar, in terms of its U.S. counterpart, has fluctuated between 80¢ and 85¢. Under this exchange rate, goods and services in Canada may be cheaper for Americans in terms of their own money. This, in theory, would constitute a stimulative effect on tourism in Canada. However, there appears to be little relationship in recent years between the number of U.S. overnight visitors to Canada and exchange rates. The exchange rate advantage may in fact be offset by the higher prices that prevail in many areas of Canada.

Three additional factors affect the **supply** of recreational opportunities and their quality. These, in turn, will ultimately affect participation rates and the value of the activities in question.

First, fish and moose are already subject to harvesting pressure in many areas of Ontario. Management efforts by relevant agencies underway to conserve and enhance fish and moose populations in the province. The availability of these species will likely depend on these efforts irrespective of acid precipitation. The extent to which waterfowl are over or under harvested is unknown at this time.

A large or substantial increase in the supply of cottages could contribute to increased participation and tourism activity. However, there are few waterfront cottage lots remaining which are convenient to urban centres and there is little evidence that there is a large demand for cottages without waterfronts. This factor implies a constraint in future recreational opportunities and slower growth.

Finally, the number of resorts and seasonal hotels has been declining, primarily due to rising costs, the growing preference for camping and the inability of many such establishments to make investments necessary to provide a wider range of recreational or resort facilities.

On the whole, acidification can further impact on these supply factors and could exacerbate these trends.

4.6 The Effects of Acidification On Sportfishing

As noted, available dose-response information only permitted the formulation of a computational procedure to estimate the effects on fish productivity and sportfishing activity.

The computational method to estimate the change in fish productivity is a two-step process. First, water bodies are classified by susceptibility to acidification and, secondly, fish losses as they relate to lake susceptibility categories are determined.

The Ministry of the Environment has classified Ontario lakes into 5 susceptibility to acidification categories:

I. Acidified Lakes
II. Extremely Sensitive Lakes
III. Moderately Sensitive Lakes
IV. Low Sensitive Lakes
V. Not Sensitive Lakes

For each category of susceptibility, the following assumptions regarding fish productivity losses for all species were made.

Category I - no fish reproduction
Category II - 20% loss in fish reproductive capability
Category III)
Category IV) - no loss in fish reproductive capability.
Category V)

For purposes of the study, reproductive capability was equated with fish productivity. Next, for each acid-sensitive region, (Figure

4.1) the percentage of sampled lake area is applied to the total lake area in the region.

The next step is to estimate fish productivity and distribute it among the susceptibility categories within each region. Fish productivity for watersheds can be estimated by use of Ryder's formula as modified by McCombie[6]. Total productivity can be allocated to each susceptibility category by extrapolating from the empirically derived sample distribution.

Current losses of fish production in existing category I waters are first estimated. Two additional scenarios are postulated to examine the potential effects of further acidification in Ontario lakes. The first scenario postulates that lakes now in category II will become category I lakes (acidified), and those in categories III and IV will also shift to the next more acid sensitive category.

The productivity losses are summed as if all lakes now in category I will lose 100% and all lakes now in category II will lose 20% of their potential fish productivity.

The second scenario presumes continued acidification to the extent that all lakes presently in categories II and III are completely acidified (Category I) and lakes currently in category IV shift to category II and lose 20% of their productivity. Estimates of annual fish productivity losses in kilograms based on these assumptions are produced.

These scenarios provide two possible "what if" examples to help illustrate possible consequences. However, more work is needed to explicitly relate acid deposition to fish productivity in a dynamic, functional sense. These relationships should encompass short term "acid pulse" effects as well as long term cumulative consequences.

4.7 Behavioural Responses To Changes In The Recreation Resource Base

Estimates of fish productivity loss are next translated into changes in angler effort.

How will anglers respond to changes in fishing quality and a reduction in the supply of fishing as measured by producitity? There are four possible responses:

a. anglers may not change their activity patterns, angler effort or their destinations.

b. anglers may switch to other recreational pursuits but not change their locational destinations. Total angler effort in Ontario will be reduced but user-occasions of other activities will be increased.

c. anglers may shift their fishing effort to other areas inside or outside the province. Total angler effort and user-occasions in Ontario may be reduced.

d. anglers may change both their activity patterns and their recreational destinations. Total angler effort in Ontario may be reduced but participation in other activities will be increased, some of which will take place within the province.

In this study, only the third possibility was considered. It was assumed that as potential fish productivity increased or declined, angler effort would increase or decline in the same direction. Changes in angler effort would, in turn, cause a change in angler success (measured by Catch per Unit of Effort - CUE).

Based on creel census data for recreational fishing in Muskoka-Haliburton lakes, a general equation relating harvest data to CUE was developed. Using productivity estimates for each region in the equations, a new CUE corresponding to that productivity level was predicted.

Consequently, as long term catch and CUE declines, long term effort is also assumed to eventually decline. Based on this assumed relationship, resulting changes can be calculated in angler-occasions and related overnight stays. Economic activity associated with these changes in effort can be estimated with the expenditures on sportfishing derived previously. These "loss" estimates may well be overstated as some of the expenditures could be spent on other activities in Ontario. The estimates of changes in productivity and angler effort indicate the magnitude of these consequences under two possible sets of circumstances. Without additional research, including surveys, it is difficult to assess whether these expenditures will be lost to the region or the Province as a whole, or what other activities might increase and offset, in total or in part, these expenditure losses.

4.8 Potential Effects of Acid Precipitation on Economic Activity in Ontario

A set of assumed relationships among lake acidification, fish productivity, sport angling effort and associated economic activity has been postulated. These results provide a sense of the dimensions of this important sector of the economy in its regional context. The focus of the study is thus on the impact of acid rain on sportfishing. At current levels of deposition in 1980, the total "loss" to the province in direct fishing-related expenditures is estimated to be about $2.7 million annually. This "loss" represents the amount of fish production and associated angling effort that could be regained if currently acidified lakes were made productive again. These effects are concentrated primarily in the Parry Sound-Muskoka-Haliburton and Northeast regions. When indirect expenditures (multiplier effect) are taken into consideration, the loss estimate for Ontario rises to $4.1 million (1980) annually.

Future losses could be significantly greater. Using a scenario which assumes that the numbers of lakes in categories I and II of the susceptibility classification increases, a 4% loss in fish productivity is

TABLE 4.5

POTENTIAL INTERMEDIATE SCENARIO FOR SPORTSFISHING

	ANNUAL ESTIMATED CHANGES IN			
	Angler Effort %	Direct Expenditures Associated with Angling ($000's)	Indirect Expenditures ($000's)	Man-Years of Employment Potentially Affected*
Parry Sound, Muskoka and Haliburton	-28	$ 7,261	$ 4,357	330
Acid Sensitive Eastern Ontario	- 2	795	477	35
Northeastern Ontario	-11	4,567	2,283	208
Northwestern Ontario	- 2	734	294	33
Total Province	- 4	$13,357	$ 7,411	606

* Based on direct expenditures

SOURCE: Currie, Coopers and Lybrand Ltd., "The Effects of Acidic Precipitation on Recreation and Tourism in Ontario", Vol. I, February 1982, Exhibit II.

TABLE 4.6

POTENTIAL WORST CASE SCENARIO FOR SPORTSFISHING

	ANNUAL ESTIMATED CHANGES IN			
	Angler Effort %	Direct Expenditures Associated with Angling ($000's)	Indirect Expenditures ($000's)	Man-Years of Employment Potentially Affected*
Parry Sound, Muskoka and Haliburton	-82	$21,191	$ 12,715	963
Acid Sensitive Eastern Ontario	-12	5,230	3,133	227
Northeastern Ontario	-29	11,598	5,799	527
Northwestern Ontario	-16	7,149	2,860	325
Total Province	-18	$45,168	$24,512	2,042

* Based on direct expenditures

SOURCE: Currie, Coopers and Lybrand Ltd., "The Effects of Acidic Precipitation on Recreation and Tourism in Ontario", Vol. I, February 1982, Exhibit II.

estimated to result. This translates into $21 million (1980) annually of direct and indirect expenditures due to a decline in sportfishing in Ontario. Under a "worst case" scenario, assuming a 20% loss in lake productivity, direct and indirect losses rise to $70 million annually. In both cases, the area hardest hit is the prime cottage and resort region of Parry Sound-Muskoka-Haliburton. Tables 4.5 and 4.6 summarize the details of these estimates.

The computational procedure used in this analysis provides a partial estimate of the monetary value of acid rain effects on sportfishing activity. These results underestimate the value of effects of sportfishing since WTP values for protecting against these effects or CR values if losses in fish productivity were to occur are not captured by expenditure estimates.

4.9 Suggestions for Future Work

The following work is required to develop a more comprehensive framework to assess and evaluate the effects of acid deposition on aquatic-based recreational activities:

a. establish direct relationships between acid deposition estimates and acidification rates on recreational lakes.

b. postulate linkages between acidification of the resource base and human uses, notably where participation rates and/or expenditures are high, including swimming, boating and hunting.

c. explore the effects of acid rain over time. Are the effects cumulative and reversible? How long will it take for resources such as lakes to recover their fish productivity? Will some resources be lost forever?

d. determine responses of users to acidification. The initial question of what will anglers do if they cannot fish is still unanswered. Some survey work indicates what they might do, but more study is needed to observe actual behaviour shifts.

FOOTNOTES TO CHAPTER 4

1 Ontario Ministry of Industry and Tourism, Tourism Statistical Handbook, May 1979 p. 20.

2 Tourism and Outdoor Recreation Planning Study Committee, Ontario Recreation Survey, 1977.

3 Ontario Ministry of Industry and Tourism, op cit, p.13.

4 Larry Smith and Associates, Economic and Social Importance of Ontario Tourism, March 1978.

5 Ontario Ministry of the Environment, Acid Precipitation in Ontario Study, Acid Sensitivity Survey of Lakes in Ontario, March 1981.

6 McCombie, A.M. Net Productivity as an Index of Cottager Impact on Fisheries, Ontario Ministry of Natural Resources, part of the Lakeshore Capacity Study, Phase III (draft).

CHAPTER 5

ESTIMATION OF THE ECONOMIC EFFECTS OF ACID RAIN ON FORESTRY, AGRICULTURE, COMMERCIAL FISHERIES AND FURS, AND SELECTED STRUCTURAL MATERIALS

5.1 Introduction

Throughout Ontario, the livelihood of many residents depends upon the Province's natural resources and a productive environment. For Canada as a whole, one job in ten is related to forestry and wood products[1]. Agriculture is also important, generating income of $5 billion in Ontario sources in 1981[2]. Other activities such as commercial fisheries and fur trapping are important for certain regions and groups, e.g. Northern Ontario and Native People.

These products are bought and sold in markets so that the value of the biophysical impacts of acid rain can be determined using market-based data and methods. At the outset, the task might appear to be a relatively simple one, however, each of these activities is both geographically dispersed and diverse. There is a wide variety of tree species which are harvested in Ontario, and many different types of crops are grown. Recalling the eight steps outlined in the estimation procedure in Chapter 2, the task of quantifying dose-response relationships, and assigning vaues for each tree species, crop or commodity becomes an enormous one.

5.2 Computational Framework

The approaches, computational procedures and receptor category models described in this Chapter were prepared by Victor and Burrell, Economic Consultants. Details of the models can be reviewed in their report, "A Methodology for Estimating the Impacts of Acid Deposition in Ontario and Their Economic Value" which was prepared for the Ministry of the Environment.[3]

Computerized models were developed to estimate the biophysical and economic consequences of acidic deposition loadings for:

a. Agriculture
b. Forestry
c. Commercial Furs
d. Commercial Fisheries
e. Selected Structural Materials

The amount of data that must be manipulated, the uncertainties associated with the various dose-response relationships and the need to make numerous analyses and reassessments of the possible effects preclude any other approach but a computerized system for this work. In addition, the computerized framework permits the addition of new data as they become available, the reformulation of dose-response relationships, disaggregation and reaggregation of results and the application of various techniques to assess uncertainties.

Five of the six receptors are terrestrial-based. All input data for the computational models concerning these categories are thus dissaggregated according to 64 regions or "site districts" in Ontario defined by Hills originally for forest inventory purposes[4]. Commercial fishing is aquatic-based and all input data for this receptor category are dissaggregated to 107 northern inland lakes which are fished commercially in Ontario.

The models are "driven" by the four key deposition loading parameters: sulphates, nitrates, ammonium and hydrogen ions. Initial values of these loadings, which are adjusted to reflect only man-made contributions, are input for each region or Lake. Only wet deposition loadings are used at this time although dry deposition input loading data can be included when these values are confirmed.

Output of the models include estimates of the biophysical effects in relevant units and estimates of the financial values associated with these biophysical changes.

The biophysical results for each receptor category are expressed in their relevant units. The economic values of the various types of biophysical effects are estimated either as an increase in costs of production (forestry, structures and materials) or as a change in producer profits (agriculture, commercial furs and commercial fishing). These estimates indicate both economic welfare and economic activity changes.

The results of each model are estimated for a user-specified period of time (normally 20 years) into the future and economic values are discounted to a reference year, in this case 1980. The monetary values that are estimated are thus present values of the effects over the desired time period.

Finally, the computerized system has a "Monte Carlo Simulation" capability to examine the effects of uncertainty. This simply means that the computer automatically recalculates the biophysical dose-response functions many times using different values in the explanatory or "independent" variable. These values are chosen from a possible range of numbers specified by the user. The results are then grouped by frequency of occurrence and the statistical characteristics of the results can be determined. These estimated biophysical consequences and associated economic values can then be expressed in probabilistic or "likelihood" terms rather than a potentially inaccurate and misleading single value result.

For each receptor category, quantitative dose-response relationships and estimates of the total quantity of resources of each type which are at risk due to acid deposition are essential inputs. And, as noted, the results for each receptor category vary somewhat and require explanation. A brief description of each receptor category model is presented in subsequent Sections.

5.3 Forestry

Acidic deposition may affect the growth of various tree species, and ultimately, the yield of wood over time. Since trees are slow growing, any damages or benefits from control programs will take years to manifest themselves. Consequently, an estimate of production changes and their relevant economic values for a single year is not meaningful. Aggregations of the biophysical and the economic consequences over at least 20 years will be necessary to capture the true effects on this sector. Moreover, such estimates, properly discounted to recognize the time value of money, are more comparable with the costs of abatement programs, which would likely be implemented over a number of years as well.

The resources at risk consist of the individual tree species that are economically important and forest communities as ecological units. There is a wide variety of tree species that are important in either context. The model incorporates data on total standing forest volumes and total wood harvest in each of the 64 regions. Data on 10 economically important species or types of trees are included as well in order to produce estimates of effects on these particular species.

Forest productivity may be affected by acid deposition through two interrelated mechanisms:

a. soil effects
b. foliar effects.

Soil effects occur when the acidic materials reach the ground and alter the physiochemical environment and microbiological processes. Foliar effects result from impingement of acidic substances on the surfaces of leaves and needles which could ultimately reduce the photosynthetic capacity of the tree (i.e. reduce the tree's ability to produce food in its leaves).

For purposes of this modelling exercise, the key relationship in the soils component was postulated to be the availability of exchangeable calcium.[4] Exchangeable calcium is determined by the net base saturation of the soil and changes in forest yield are stated as a function of exchangeable calcium. Acidification is postulated to reduce the exchangeable calcium levels and thus reduce forest productivity. On the other hand, nitrogen deposition has a fertilizing effect on soils and so can enhance forest growth. Sulphur deposition is assumed to have no fertilizer effect. Since these relationships have opposing effects, one can only determine the net effect through empirical analysis.

A number of researchers postulate that free aluminum and possibly manganese may be toxic to tree roots, however, no quantitative relationship is available that could be incorporated into the model at this time.[6]

The potential foliar effects of acid deposition have been postulated by first grouping all major commercial tree species into three sensitivity categories as listed below.

SENSITIVITY OF FOLIAGE TO ACID DEPOSITION BY COMMERCIAL TREE SPECIES

Tolerant	Intermediate	Sensitive
Spruce	Jack Pine	Maple
Cedar	White Birch	Yellow Birch
Fir	Ash	White & Red Pine
Oak	Elm	Poplar

SOURCE: Victor and Burrell, "A Methodology for Estimating the Impacts of Acid Deposition in Ontario and Their Economic Value", June 1982, p.3-31.

The pH of rain threshold values for these three sensitivity categories have been postulated. At or below these values, reductions in photosynthetic capacity will occur. As the pH of rain declines, the reduction in photosynthetic capacity increases to 100% and death of the tree is assumed to occur.

There is a great deal of uncertainty about which pH of rain values will initiate leaf damage or cause 100% loss in photosynthetic capacity. Therefore, pH values at which photosynthetic capacity might be reduced by 100% and by 0%, for each sensitivity category, have been postulated for Monte Carlo Simulations.

The percent change in photosynthetic capacity is then used to estimate the percent reduction in wood production. The model postulates that for every 1% reduction in photosynthetic capacity, there is a corresponding percent reduction in productivity up to a loss in leaf area of 75%. Beyond that point, there is a 1:1 relationship.[7]

The changes predicted by the soils component of the model are thought to be permanent and are thus carried over or accumulated from year to year. On the other hand, the foliar effects occur each year and are not cumulative. Trees have the potential each year to produce the maximum yield permitted by the previously accumulated soils effects but this yield may be reduced by foliar effects.

The percent change in wood yield for a given year is the summation of the soil and foliage effects. Again, because some effects are potentially stimulative as well as adverse, the net change can only be determined empirically. The net change in yield, for each species and for total harvest, is estimated from allowable cut data in each region for the first year. This is expressed in cunits, a measure of volume commonly used in the forestry industry. The yield in each subsequent year is derived by subtracting this estimated reduction for the given year from the yield of the preceeding year.

The forestry model generates, in a single-valued or a probablistic format, the predicted harvest of wood from all species and by selected species resulting from acid precipitation effects in each year over the period of analysis. The difference between these predicted harvests and potential harvests are the net losses due to acid precipitation.

Throughout much of the province, the actual cut of each species is less than the allowable cut and is likely to remain so through the

remainder of this century. Thus, it is assumed that the forestry industry will continue to harvest the same total quantity of wood over time and total revenues will, therefore, not be affected. Instead, the trees will be more costly to harvest if acidic deposition curtails long term growth and forest productivity.

In the model, it is postulated that total cost changes will result from changes in tree size so that, in any given year, costs will increase or decrease proportionately to changes in tree size due to acidic deposition. These proportional change factors are derived from the dose-response relationships.

Cost changes are reported by the model. Estimates of changes in "value added" or any other relevant economic indicator can then be made by the user.

Many of the biophysical dose-response relationships postulated in this model are tentative and subject to review. However, they can be modified and changed as required.

5.4 Commercial Furs

There are about 20 species of commercially valuable fur-bearing animals in the province. Data for the 1979-1980 commercial fur harvests (total pelts) and quotas were obtained from the Ministry of Natural Resources by administrative district and disaggregated to the 64 regions.

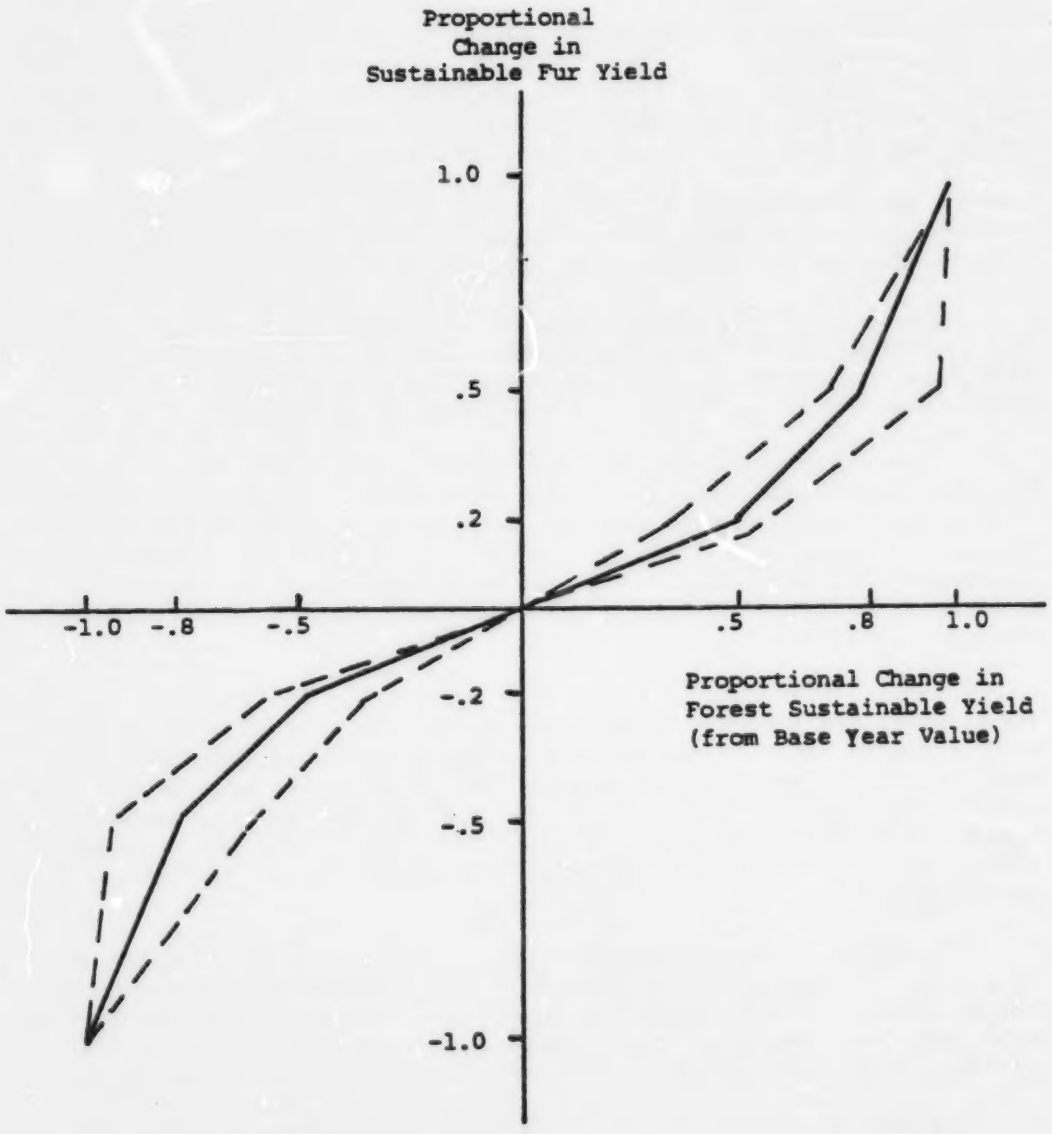
No experimental information or conceptual papers concerning the effect of acid deposition on fur-bearing species could be found by the Consultant. Consequently, a generalized relationship between the production of the relevant fur animal populations and forest productivity changes was postulated. This formulation can be altered if a more accurate relationship between this or other indicators (e.g. water quality) is provided.

The relationship between fur harvest and forest productivity is presented in Figure 5.1. The percent increase or decrease in fur production, based on estimated changes in forestry production, can be obtained directly from this diagram. The Monte Carlo Simulation can be employed to vary this relationship between the values shown by the dashed lines.

In order that there be an economic consequence, the number of pelts actually harvested will have to be affected by the pollution phenomenon. In Ontario, quotas for some animals are set by the Ministry of Natural Resources. In many areas, trappers actually harvest fewer animals than specified in their quota. While acidic deposition may reduce the biological productivity or the potential harvest of the various species, a real economic loss will be experienced only when the actual harvest of a particular species is at or near the sustainable yield. In the model, it is assumed that all species are being harvested at their sustainable yield and any change in productivity will result in a change in the number of pelts taken.

FIGURE 5.1

ASSUMED RELATIONSHIP BETWEEN FOREST PRODUCTIVITY AND SUSTAINABLE COMMERCIAL FUR YIELD



SOURCE: Victor and Burrell, "A Methodology for Estimating the Impacts of Acid Deposition in Ontario and Their Economic Value", June 1982, Fig. 5.1.

5.5 Agriculture

Agriculture is important from both an economic and a social perspective. The industry, from farmers to food stores, is the basis of a substantial amount of economic activity and employment. Governments and society have demonstrated a willingness to provide public assistance in order to maintain opportunities for farming and to enhance agricultural activity in the province. For these reasons, the potential effects of acid deposition on agriculture merit close consideration.

The resources at risk consist of the large variety of crops which are grown primarily in Southern Ontario. Data on the production of 36 crops for the year 1979 were disaggregated to the 64 regions in the province. Nearly all of this production occurs in the Southern portions of the province where acidic deposition rates are highest.

As with forests, the dose-response mechanisms that affect crops consist of both soil and foliar effects. Soil effects include acidification and the addition of nitrogen and sulphur to the soil.

Farmers have long had to deal with soil acidification resulting from the application of nitrogen fertilizers. Regular application of lime is, therefore, practiced where large quantities of fertilizers are used and/or where soils have a naturally low buffering capacity.

In the model developed for the agricultural sector, it is assumed that the farmer will respond to the soil effects each year by adding lime to maintain soil pH and by reducing the amount of nitrogen and sulphur fertilizer from what would be required without deposition. Consequently, assuming that soil conditions and fertilization are maintained at optimal levels, crop yields are not expected to be affected through soil effects.

However, the costs of liming and fertilization will be affected. If farmers are not liming and fertilizing their soils in an optimal manner, cost estimates will be overstated or understated accordingly. For example, if a farmer is not adding lime to his soils, crop yields may decline through acidification (in addition to any changes caused by foliar effects) and the value of this reduction in production must be added to the value of increases or decreases in liming and/or fertilization.

It should be noted that changes in soil chemistry are partially reversible through soil management. Thus, even though a farmer may not be adding lime or fertilizer each year in an optional manner, the total adverse effects on crop production over the long term (10-20 years) may be partially offset by appropriate management techniques.

The effects of acidic deposition on crop production via foliar effects is the subject of great uncertainty and substantial, as yet unreported, research effort. However, initial dose-reponse relationships for the various crops were postulated from the available literature and used in the model.

TABLE 5.1

ACID RAIN SENSITIVITY OF AGRICULTURAL CROPS

Crop Groups	Specific Crops
Root crops	- beets, carrots, parsnips, radishes, rutabagas
Leaf crops	- lettuce, celery, spinach, tobacco, asparagus
Cole crops	- cabbage, cauliflower
Tubers	- potato
Legumes	- green beans, white beans, soybeans
Fruit	- apples, cherries, grapes, peaches, pears, plums, raspberries, strawberries, peppers, cucumbers, tomatoes
Bulbs	- onions
Grains and Forage Grasses	- wheat, oats, barley, fodder corn, sweet corn, green corn, hay, mixed grains

Sensitivity Rating

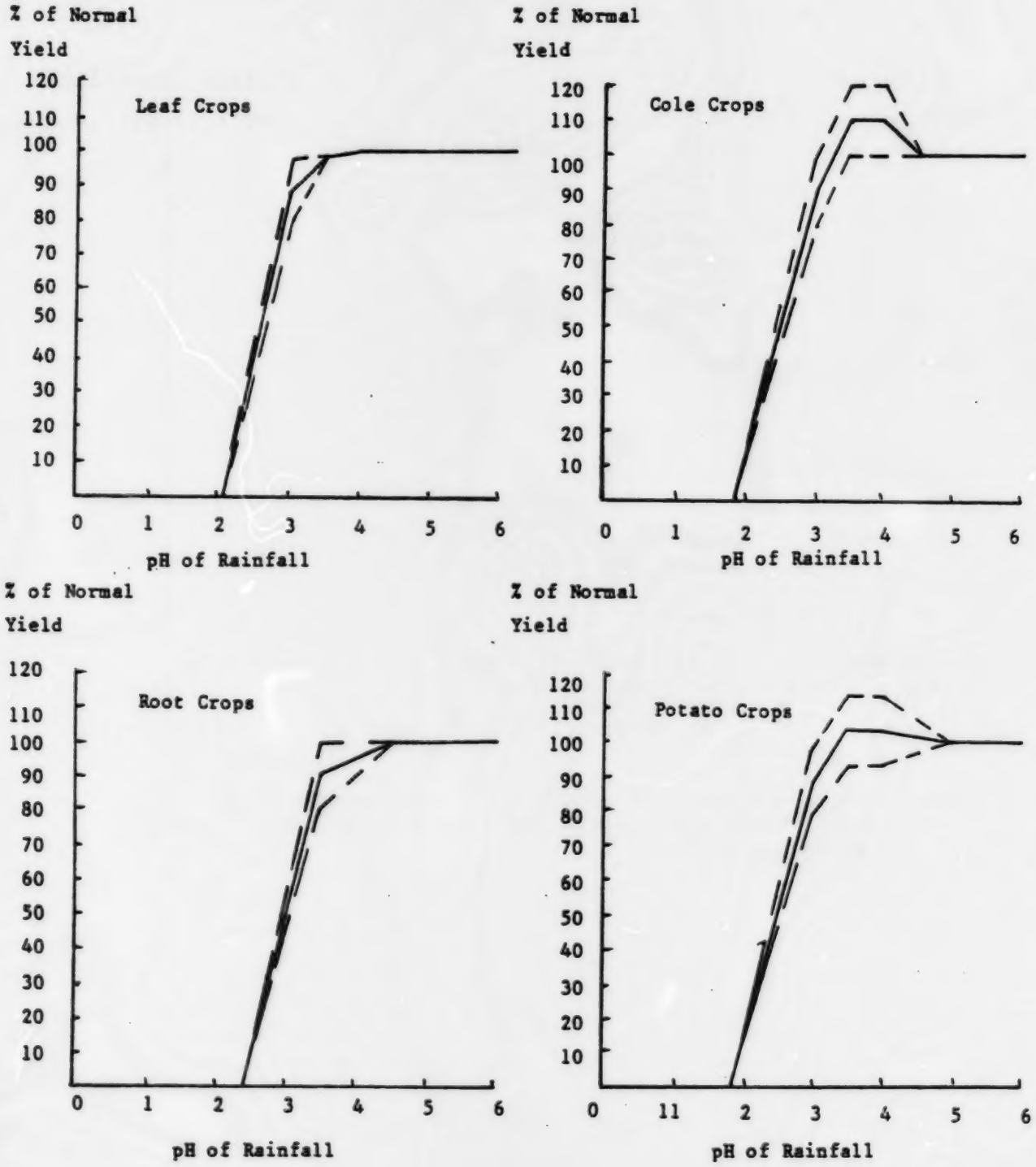
Most Sensitive

Most Tolerant

SOURCE: Victor and Burrell, "A Methodology for Estimating Impacts of Acid Deposition in Ontario and Their Economic Value", June 1982, pp. 4-11, 4-12.

Figure 5.2

Dose - Yield Response Curves: pH of Rainfall and Yield of Agricultural Crops



SOURCE: Victor and Burrell, "A Methodology for Estimating the Impacts of Acid Deposition in Ontario and Their Economic Value," June 1982. Fig. 4.1

Specific crops were assigned to "sensitivity groups" as listed in Table 5.1. This classification is based on the yield effect on marketable portions of the plant. Dose-response curves relate the percent of normal yield of the crop sensitivity group to the average annual pH of rainfall. Examples of these curves are illustrated in Figure 5.2. Given the uncertainty about the foliar effects of acidic precipitation, application of the Monte Carlo Simulation capability is important.

Estimates of future crop production are needed to compare with production estimated under different acidification scenarios. Because no official projections of crop production are made by Provincial or Federal Government agencies, estimates of the future production of each crop had to be produced as part of this study. These annual crop production estimates are then multiplied by the factors derived from the foliar effect dose-response functions described above.

The economic value of changes in crop production could therefore be obtained by multiplying the estimated increase or decrease in the production of each crop in relevant units by an average 1980 price for the crop in question. It is assumed at this stage that there are no changes in crop prices or crop production costs that result from acid precipitation effects. The economic value thus estimated is the change in profits to farmers. If the predicted changes in crop production under different pollution scenarios are very large, the price of the agricultural products could change and this new price should be used to calculate revenues and profits. The change in WTP or CR value to consumers of a price change would also have to be calculated.

5.6 Selected Structural Materials

Various authorities have suggested that acidic deposition might adversely affect buildings, materials that are exposed to precipitation, historical structures, archeological treasures and water supply systems.

There are no comprehensive inventories of buildings or other man-made facilities of economic, historical or cultural importance which might be used to assess the effects of acidic deposition. Consequently, the model was developed using only data on the value of consumption for six types of materials: concrete, zinc, aluminum, copper, nickel, and paint. The relevant data for 1979 concerning these materials were disaggregated by the 64 Hills site regions.

The likely effect of acidic deposition on materials is corrosion. However, there is virtually no experimental information on the relationship between corrosion of various materials and wet acidic deposition. There is, however, a considerable body of experimental results on the corrosion effects of SO_2 and other gaseous contaminants.[8] Therefore, dose-response functions for the six different materials were extrapolated from known relationships between ambient SO_2 concentrations and corrosion. Other materials may be affected as well but the six noted above constitute a large proportion of the economically important substances. Moreover, data are already available for these materials.

The most appropriate and accurate approach would be to estimate the extra corrosion, repair and replacement on the stock of materials and structures that is due to the pollutant. However, relevant inventory data of this stock are not available. Therefore, the method used to estimate the economic value of the materials that are lost through corrosion was adapted from Salmon.[9] Since this approach was designed for SO_2 effects, adjustments had to be made to handle wet sulphate deposition. The key adjustments are:

a. Salmon's "**exposure factor**" for each material is reduced by 50% to reflect the fact that less surface area will be exposed to acid rain than to gaseous SO_2.

b. The annual corrosion rate (Salmon's "**interaction value**") is reduced by 40% to reflect the fact that sulphates in rain are likely to be in contact with materials for a shorter time than air-borne pollutants.

These adjustments have the effect of reducing the corrosion rate for water-borne sulphates to 20% of the corrosion rates that are associated with gaseous SO_2. This figure probably errs on the "conservative side", yielding an underestimate of damages. Corrosion associated with dry deposition would likely be 100% of the equivalent SO_2 corrosion relationship. Because of the uncertainty concerning the actual corrosion rate or the interaction factor, a probablistic range has been specified for application of the Monte Carlo Simulation technique.

People respond to increased corrosion by applying protective coatings (paint, plating, etc.) and by accelerating maintenance and replacement schedules for the affected structures. Where municipal or communal water supply systems are affected, pH can be adjusted through the addition of chemicals at a cost. Acidity may also accelerate corrosion in certain parts of the water system.

For structures of historical, cultural or archaeological importance, protection and preservation rather than replacement usually become the key goals.

The value of the corrosion effects caused by the pollution is equal to the costs of the extra cleaning, preservation, maintenance and replacement activities necessitated by pollution. Where historical or culturally important structures and artifacts are affected, amenity values over and above the financial values of repair and preservation may be relevant. In the model, the monetary value estimated primarily represents materials replacement. Amenity values are not included in this analysis.

To the extent that structures or artifacts of historical, archeological or anthropological interest can be repaired or restored, the financial value of such effects can be estimated. The Ontario Heritage Foundation has cost data on a number of restoration projects across the Province. If acid deposition effects on historically or archaeologically important structures are irreversible, non-restorable losses, the value of the welfare loss to society would be an amenity value which would require a contingent value survey to estimate.

In any event, estimates of the likely physical effects of acidic precipitation on materials and structures are fundamental to this analysis whether financial or amenity values or both are concerned.

5.7 Commercial Fisheries

Fish in lakes and rivers may be harvested by three types of users: a) commercial fishermen, b) recreational anglers, and c) food or subsistence fishermen, primarily Native People. In this section, the consequences for commercial fishing are examined. Because many Native People are involved in commercial fishing along with harvesting fish for their own food requirements, the socio-economic implications for subsistence fishing will be noted as well. The potential impact of acidification on recreational angling has been addressed in Chapter 4.

Commercial and subsistence fishing are carried out on the Great Lakes and on many of the larger inland lakes in Northern Ontario. Commercial fishing in Ontario employs a total of about 2,200 people, of which at least 600 are involved in the Northern inland fisheries.[10]

Fish populations in the Great Lakes do not appear to be threatened by acidic deposition because they have such large reserves of buffering capacity. There are, however, two potential problems concerning the Great Lakes which could arise from acid deposition. Tributaries to the Lakes which serve as spawning grounds for some fish species could be subject to long term acidification as well as "acid shocks" during spring runoff. Furthermore, the sediments in estuaries around the Lakes could be accumulating loadings of heavy metals released by acidification. These heavy metals have been shown to find their way into food chains where they bio-accumulate in fish and other aquatic organisms.

The Northern inland lakes are potentially vulnerable to acidification and, therefore, are at risk. There are approximately 226,900 inland lakes in Ontario with a total surface area of 22.4 million hectares.[11] At least 107 inland lakes are fished commercially and all of these are located in Northern Ontario. The Ministry of Natural Resources assigns quotas to the commercial and Native fishermen who operate on these lakes.[12]

Commercial fishermen harvest about 30 different species and varieties of fish. Walleyes, perch, smelt, lake trout and whitefish are the most important commercial species. These fish species exhibit different degrees of sensitivity to acidity. Accordingly, data on 107 commercially fished, inland lakes and 10 fish species were assembled for application of the fisheries component of the model. In addition, these 107 lakes are identified within the 64 regions.

The dose-response relationships postulated for this computational framework are based on a model developed in 1982 for the Federal Department of Fisheries and Oceans.[13] The basic approach developed in this procedure is to estiamte the alkalinity contributions to a lake system from various sources and then predict how an acid loading would affect this supply of buffering material. The predicted chemical

changes are then related to changes in fish yield through alterations in a lake's alkalinity concentrations based on a relationship known as the Morphoedaphic Index (MEI). The index was developed by Ryder to estimate natural fish production or the maximum annual sustainable yield (MSY) of a lake.[14] This index was developed specifically for Northern Ontario waters and is used extensively by fisheries managers in Eastern Canada.[15]

The basic premise is that, as alkalinity is depleted by acidification, the loss in the long term, sustainable yield in fisheries can be predicted. However, this approach does not incorporate any effects of the "acid shock" that occurs during spring runoff.

This biophysical component of the fisheries model consists of two sections: physical-chemical changes and biological responses.

The physical-chemical component links acidic deposition to an annual alkalinity or acid neutralizing capacity (ANC) budget for a lake or watershed. Sources of the ANC include overland runoff, groundwater, autochthonous matter and residual lake alkalinity. The yearly hydrogen ion input from the atmosphere is compared to the store of ANC on an annual basis and the resulting increase or decrease in lake alkalinity is predicted. The net alkalinity concentration and the pH of the lake are estimated using data or estimates of the water flows for each lake or watershed system.

The annual changes in alkalinity and pH in each lake over time are calculated by substituting the predicted alkalinity for the initial alkalinity in subsequent model computations. The model can be run for a fixed number of years or until a critical pH is reached. Moreover, by varying the hydrogen ion deposition figures in the calculations, the effects of different acid loading scenarios on lake alkalinity can be estimated.

The biological response component is based on a modified Morphoedaphic Index. The formulation used in the model produces an estimate of annual gross fish production each subsequent year directly in kilograms. Production changes due to acid deposition are determined by estimating production levels under different deposition scenarios and calculating the differences in fish yields.

This production estimate includes all species of fish. In order to assign a proportion of a lake's total sustainable yield to that component of the fishery which is harvested commercially, each lake was assigned to one of 15 fish community types. Each community type had a unique percentage distribution of the 10 fish species.

If acid deposition reduces the long term MSY, several types of human responses are possible and must be considered. If sport fishing is also occurring in the lakes, decisions on allocating the reduced MSY among commercial, sport and subsistence users must be made by management authorities. If commercial catches are not regulated, fishermen may increase their effort as productivity declines. As with forest production, the harvest will remain the same but costs will increase. If commercial catches are below quotas and/or the biological MSY, as is the case on many lakes, no reduced catch will be noticed and there will be no responses by management authorities or by fishermen.

Thus, in order to estimate an economic effect, certain assumptions must be made about current commercial fishing operations. Three possibilities are permitted for in the economic component of the fisheries model:

a. For species subject to quotas and harvested at or near the quota (defined as 75% or more of the quota), any reduction in the biological MSY can result in an economic loss.

b. For species not subject to quotas, but harvested at or near MSY (i.e., equal to or greater than 75% of MSY), any reduction in MSY will result in an economic loss.

c. In all other cases, where harvest is less than 75% of the quota or MSY, reductions in MSY will not result in changes in harvest or in economic consequences.

The economic (financial) value of any change in harvest is equal to the kilograms of each fish species times the appropriate price per kilogram of the fish species. Changes in the costs of harvesting should be subtracted as well, although it is likely that changes in the costs of fishing in inland waters would be negligible. The increase or decrease in revenues from fish sales is, therefore, considered to be a measure of fishermen's profits as well as economic activity.

Changes in fishermen's profits attributable to acidification represents the financial value of the welfare change to society. There may also be some amenity values associated with commercial fishing but these are not addressed in this study.

Harvest data for 1979 are presently used in the computational model and no changes in future annual harvest are projected. The assumption of a more or less constant level of harvest is consistent with the historical record for the aggregate of Northern inland lakes since 1941.[16]

Implications for Native People can be investigated by assembling data on the numbers of Native fishermen on each commercially fished lake. Since the model will provide estimates of changes in fish production on each lake, an indication of the impacts on each Native fishing group, as well as non-Native Northern Communities where commercial fishing provides a source of income, can be made.

Although the model produces estimates of the economic effects on commercial fishing, the biophysical changes in long term fish productivity will affect the fish available for recreational angling as well. The uncertainties inherent in the chemical and biological components of the model impose rather wide confidence limits on the actual estimates. Nevertheless, the model can be used to indicate which lakes are most likely to be subject to use conflicts and economic effects.

5.8 Conclusions

The computerized models described in this Chapter provide extremely powerful tools for analyzing the damages of acid deposition and the benefits of control strategies. The models can easily be edited to add new inventory data, reformulate dose-response functions and expand the scope of the exercise as required.

Although the dose-response functions for the various receptor categories are subject to review and revision, initial analyses with this tool reveal a number of important insights. First, potential consequences of acidic deposition on terrestrial receptor-categories may be far more extensive than had previously been considered. This finding contributed to a shift in emphasis to terrestrial studies by the Ministry's acid precipitation research program.

Second, the models clearly show that one cannot make simplistic, linear assumptions about deposition and effects. There are many intermediate relationships and there are some potentially beneficial, as well as adverse, effects due to acid rain. The net effects, both biophysical and economic, can, therefore, only be determined by means of an iterative, computerized computational system such as has been developed here.

Finally, this work has shown where more biophysical work and information is required and indicates to those researching the effects of acid deposition on forestry, agriculture, fisheries and materials, what specific kinds of data and information are required for strategy development, analysis and evaluation.

FOOTNOTES TO CHAPTER 5

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CHAPTER 6

CONCLUSIONS AND FUTURE WORK

The following conclusions and points of emphasis can be made on the basis of the work to date.

The basic objectives of these studies were threefold:

a. To test theoretically sound methods for determining the value of pollution effects and of environmental resources.

b. To develop frameworks for estimating the relevant biophysical effects of acid rain and assessing the economic implications of these effects.

c. To make quantitative estimates of these effects and implications.

Previous work by the Ministry of the Environment identified the theoretical basis for estimating the economic values associated with environmental effects and resources.[1] Despite certain limitations, monetary values can be used to express the relative importance to society of various tangible and intangible effects of pollution and its control. Where resources will be protected or if people will gain something from an environmental protection action, then the appropriate value measure is the maximum amount people are willing to pay (WTP) to achieve these benefits. If damages have already occurred or people will experience environmental deterioration as the result of some action, the appropriate monetary value is the minimum amount of compensation required (CR) for people to perceive themselves as well off as before.

Two broad types of monetary value measures are used in economic analyses. First, there are values which represent changes in economic welfare. These values indicate whether an individual or society is better or worse off as a result of an effect or an action. Economic welfare consists of two component values - financial values and amenity values. The second measure represents changes in economic activity, including employment. Economic welfare, and not economic activity, measures are the appropriate values to be used in cost-benefit assessments.

Many environmental effects or resources embody both financial and amenity values. For example, the financial value of sickness is represented by lost wages and by health care expenses. However, people may be willing to pay additional amounts of money to avoid (or reduce the risk of) pollution-related illnesses. Alternatively, people require extra compensation to endure pain and suffering of disease. In any event, the full value of changes in welfare that are associated with environmental effects is the sum of the financial and the amenity values. In addition, estimates of changes in economic activity indicate the distributional consequences of these effects.

The two fundamental approaches for obtaining empirical estimates of these economic measures include:

1. Ask people directly what they spend, are willing to pay or require in compensation for actual or hypothetical environmental changes (e.g. damages, improvements or protection of current quality levels).

2. Market-based methods which utilize:

   a) direct linkages between environmental effects and changes in costs and/or revenues of production activities and enterprises; and

   b) indirect linkages between environmental effects and changes in the consumption or use of marketable complementary or substitute goods and services.

The Amenity Value Survey is an application of the first approach and provides willingness to pay value estimates of both users and non-users to protect environmental resources that are vulnerable to acidification. The Tourism and Recreation Study employed the second approach, specifically 2a, in order to obtain estimates of potential economic activity changes. Implications for economic welfare associated with threatened recreational activities were not determined in this study.

The third investigation, the "Financial Value Study", is an example of the second approach as well. Direct linkages (dose-response relationships) among acid deposition, selected biophysical effects and changes and their economic implications have been postulated and assembled into a computerized computational framework. Both economic activity and certain aspects of economic welfare changes are estimated by this framework.

The Financial Value Study was successful in developing a computational framework that permits iterative analyses of acid rain damages and the consequences of SO_2 abatement programs. The framework developed in the Tourism Study lacks a direct empirical link with acidification that is necessary for analyzing specific abatement scenarios. In addition, the relationship between relevant biophysical effects and recreational behaviour responses requires further development.

The Amenity Value Survey provides a basic questionnaire that can be applied at a future time or in other locations for comparative purposes. The study also provides the basis for developing similar surveys for other environmental problems and issues in the Province.

These studies have produced a wealth of valuable quantitative information about the effects of acid precipitation, resources and activities at risk in Ontario and the economic valuation of these resources and activities. Moreover, the Amenity Value Survey results indicate that a large proportion of the people sampled were in favour of greater environmental protection despite the economic costs. In particular, the Tourism and the Financial Value Studies have assembled a solid base of relevant data that can be improved and built upon. Moreover, these studies have postulated explicit biophysical dose-response and behavioural relationships which can be queried, assessed and changed if necessary.

However, any single set of estimates of the economic implications of acid precipitation from these studies is subject to a number of limitations and qualifications. First of all, the willingness to pay values from the Amenity Value Survey or the "expenditure loss" estimates from the Tourism Study cannot be compared directly with any currently published set of abatement costs.

Another problem is that, as they are currently formulated, dollar value estimates from each study are not directly comparable with each other. Additional steps must be taken before these estimates could be meaningfully aggregated. For example, the economic values generated by the forestry, agriculture, furs, materials and commercial fishing models are total present value estimates over a user-specified period of time (20 years). On the other hand, the sportfishing "expenditure loss" estimates from the Tourism Study are annual figures and are not discounted. Moreover, the effects on sport fish and fishing must be linked more directly to specific acid deposition loadings in order to make the biophysical and economic results in the Recreation and Tourism sector directly comparable with the Financial Value Study models.

Finally, there is a great deal of uncertainty about the biophysical and behavioural dose-response relationships and assumptions used in the Tourism and Financial Value computational models. These assumptions and relationships are therefore, subject to further review and debate. In the meantime, a single set of estimates of effects and monetary values has little meaning. The computational procedures can be most usefully applied to test a variety of different assumptions and possible relationships. Only after these types of analysis and exercises can a range of meaningful estimates emerge.

Alternatively, the Monte Carlo Simulation procedure can be applied to the agriculture, forestry, materials, furs and commercial fishing sectors to obtain estimates of the probabilities that different levels of effects could occur. This is fundamentally more accurate and far less misleading than saying that "acid rain may cause a loss of $x million per year".

These studies have also placed some important bounds on the potential scope and magnitude of acid rain effects. For example, based on current knowledge, acid deposition will likely materially affect the following types of recreational activities: aquatic-based activities such as swimming, fishing, boating, scuba diving and water skiing; and hunting of waterfowl and moose, animals which depend on aquatic environments. Of these activities, available scientific information indicates that swimming, boating, other water contact activities and hunting are not affected by the current deposition loadings and levels of acidification. Acidification effects on tourism in Ontario will thus be felt principally through recreational fishing.

An important result of the Financial Value Study and a limited application of the various receptor-specific models is that the potential consequences of acidic deposition on terrestrial receptor categories are far more extensive than had previously been considered. This conclusion contributed in part to an allocation of more resources to the

terrestrial effects component of the Ministry's Acid Precipitation research program.

These studies have also shown where more information is required to improve the models and enhance their use for policy analysis. In particular, more generalized dose-response relationships among acid loadings, acidification of lakes, fish production and recreational fishing as well as swimming, should be developed. These functional relationships may require the assembly of more extensive, lake-specific biophysical data as is required for the commercial fishing model developed in the Financial Value Study. Specific suggestions for improving the various frameworks and models can be found in each report.

Consequently, although the Amenity Value Survey shows that there is strong public support for greater environmental protection and that many people are willing to pay a positive sum of money in higher prices and taxes to preserve aquatic ecosystems, it is not yet clear which particular deposition level will produce the greatest amount or value of benefits for the abatement money spent. This question can be explored by estimating the changes in damages resulting from different SO_2 abatement strategies in eastern North America. Least-cost abatement strategies to achieve any given SO_2 deposition level can be determined with the LRTAP optimization procedure (or Screening Model) that was developed for the Ontario Ministry of the Environment.[2]

The investigations described here provide the capabilities for assessing the benefits of acid rain control strategies. While these frameworks can be improved, the models are sufficiently developed to begin the task of examining the benefits of control strategies in a quantitative and systematic manner.

FOOTNOTES TO CHAPTER 6

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2 "Linear Programming Screening Model for Development and Evaluation of Acid Rain Abatement Strategies". Prepared for the Ontario Ministry of the Environment, Policy and Planning Branch by Edward A. McBean and Associates, Ltd., September 1983.

APPENDIX A

GLOSSARY

Acid Deposition

A process by which substances capable of chemically donating a proton, or positive hydrogen ion, are deposited on the earth's surface, thereby tending to shift receiving substances towards the acid end of the pH scale. Deposition may occur during precipitation (rain, snow or fog) by the removal of suspended or gaseous material from the air, or in dry form when particles such as fly ash, or gases such as sulphur dioxide or nitric oxide are deposited or absorbed onto particulate surfaces.

Alkalinity

The quantitative capacity of water to react with a strong acid to a designated pH. The alkalinity of many surface waters is primarily a function of carbonate, bicarbonate and hydroxide content.

Allowable Cut

The amount of forest products that may be harvested annually or periodically, from a specified area over a stated period, in accordance with the objectives of forest management authorities.

Amenities

Attributes of resources, things or concepts giving pleasure to people, but not usually having an established price in the market place, e.g. the existence of wild animals or birds, clear views of scenery, etc.

Amenity Value

A monetary value that is estimated for or attributed to an amenity.

(ANC) Acid Neutralizing Capacity

The ability of substances such as water or soil to maintain the concentration of hydrogen ions within a given range by neutralizing any added acid.

Autochthonous Matter

Organic and inorganic material (leaves, sticks, etc.) that fall or are washed into a lake or stream; originating from outside the lake or stream.

Benefits

In the context of this report, benefits are the damages to humans or to the environment that are prevented, reduced or avoided as a

result of abatement or mitigation efforts. Benefits are thus derived from damage estimates.

Complementary Goods and Services

Goods and services which are purchased and used in conjunction with each other such as bread and butter, automobiles and fuel, outdoor recreation and travel costs.

Consumer Surplus

The difference between the maximum amount that people would be willing to pay for something and the amount (price) they actually have to pay for it. Technically, this is the integral of the area under the demand curve for a good, above the price of the good. This monetary value represents at least part of the enjoyment and welfare people receive from a good.

Contingent Market

A hypothetical market situation devised for the purpose of a Contingent Value Survey. People are asked their WTP or CR values for goods, services or attributes not normally bought or sold.

Contingent Rank Ordering Method

A method of eliciting WTP values from respondents to a questionnaire. Individuals indicate their rank combinations of environmental quality levels and option prices. A statistical procedure is employed to estimate their WTP.

Contingent Valuation Method

By means of a survey or questionnaire, respondents are presented with a hypothetical or contingent market for goods, services or attributes not normally bought and sold. Different techniques are employed to elicit WTP or CR values for the features in question.

(CR) Compensation required

The amount of money people would require to give up something. Market prices are CR values because they represent the value that producers are willing to accept to "give up" their products. Contingent value surveys also ask people their CR to give up amenities or incur damages.

(CUE) Catch per unit effort

The number, size, type and quality of fish caught for a given amount of psychic and physical exertion.

Cunit

A unit of stacked wood containing 100 cubic feet of solid volume.

Damages

Adverse effects on people resulting from environmental changes. May be measured in biophysical units and then weighted in monetary values.

Demand Function

A schedule of price-quantity combinations which show how much an individual would be willing to pay for different quantities of a good. A market demand function is the aggregate of all individual demand functions and shows the total quantities of a good that would be purchased or demanded at different prices.

Dose-response relationship

The connection between the quantity (dose) of pollution intensity (acidic deposition) experienced by a defined area or organism, and the physical changes (response) resulting from it.

Economic value

Worth or desirability as determined by the amount of money or goods people are willing to pay in exchange. As distinct from aesthetic or moral value.

Exchangeable Calcium

The amount of basic calcium cations in forest soil and in a form that is available for uptake by trees and other plants.

Financial value

A monetary value of an effect, goods or services that is based on market prices of marketed goods and services.

Hedonic (attribute) price approach

A method of estimating the monetary value of something which has no established price, by assigning to it those parts of known actual expenditures by many persons on complementary or collateral goods and services, in order to impute an average or normal value to the pleasurable activity.

Imputed market methods

Means of attributing or ascribing a monetary value to things which normally are not bought and sold, by analysis of behaviour and values of marketable goods and services which are complements or direct substitutes for the non-marketed features.

Indirect Expenditures

When a dollar is spent in a community, the person (merchant, etc.) who receives the dollar will spend it again to pay bills or purchase

other goods and services. In this way, further economic activity is generated from the initial, direct expenditure.

Information bias

In public opinion and contingent value surveys, a bias in responses caused by the fact that some respondents have more information than others about the subject matter in question.

Legacy value

The worth or desirability of a thing, in market, aesthetic or moral terms, if passed on intact to future generations of man or other organisms.

LRTAP

Long Range Transport of Air Pollutants by means of air currents and moving weather systems.

Market valuation methods

Means of estimating the monetary worth or desirability of commodities by reference to the prices paid for them in established markets.

(MEI) Morphoedaphic Index

Morphoedaphic index, which is one indicator of sustainable annual fish yield, obtained by dividing total dissolved solids by the mean depth of water.

Monte Carlo Simulation

The Monte Carlo Simulation procedure is used to solve a model many times with different values from a given probability distribution of the explanatory variable. The values from the model solutions are statistically analyzed so that probabilistic statements about the results can be made such as, "there is a 10% probability that the effect of acid rain on a particular receptor will change its yield by 38% or more and a 90% probability that this change will exceed 12%". Monte Carlo Simulation overcomes the inherent inadequacies of single point estimates by producing results which support statements about the level of risk involved.

(MSY) Maximum Sustainable Yield

The maximum quantity of fish, animals, wood or other harvestable resources that can be removed or cropped annually from a given population without a resultant population collapse.

Multiplier

The sum of secondary or direct expenditures on goods and services following an initial direct purchase, caused by the fact that the

original seller has additional money to spend, and expressed as a ratio of the initial expenditure.

Net Base Saturation of Soil

The percent of exchangeable basic cations available in a soil.

Net Factor Income Approach

The change in profits to producers attributable to an environmental effect. This may result from a change in the costs of producing a given level of output or from a change in output with little or no change in costs of production.

Option Value

The amount people are willing to pay to preserve or maintain a resource or an opportunity for their future, personal use.

Payment Mechanism Bias

In a contingent value survey, the mechanisms by which respondents are told they might actually pay their WTP or CR valuation might introduce a systematic under- or over-statement of their true valuations. For example, if higher electrical utility prices are the payment vehicle for the contingent market, the respondent may understate his WTP because he doesn't want to support the power company.

Perfect Substitutes Approach

A means of measuring the financial value of an environmental effect based on the costs of changed inputs needed to achieve exactly the same physical results, for instance, the costs of restoring a lake to its previous condition.

Present Value

The value at the present time, of a dollar spent or received in the future. A present value is calculated from a future value by means of a procedure called discounting.

Producer Surplus

The profits made by a firm or an individual from selling a product or service after all costs are paid out, including a "normal" return on investment.

Property Value Method

The real estate value of a parcel of land, which can be compared with a like parcel in order to estimate the monetary value of environmental damage.

Public good

A thing or amenity to which people have shared access, and in which there is no private ownership by an individual or business. Public goods may be natural, as in clear visibility, or man-made, as in historical monuments.

Starting point bias

In contingent value surveys, a systematic error in results or estimates that results when respondents are given an initial or "starting point" WTP value to start the contingent value bidding process.

Strategic Behaviour

In contingent value surveys, a bias reflecting a perception that the respondent may have something to gain or lose by stating a WTP value that is higher or lower than his "true" WTP.

Subsistence Fishing

Fishing for food and home consumption as opposed to fishing for sport or commercially.

Use value

The total utility, satisfaction or need-fulfillment yielded by the object in question.

User Occasion

A measure of recreational activity in which any part of a day is spent participating in a particular activity, such as swimming.

Value of Human Capital

The financial value of mortality or morbidity as measured by health care costs, lost wages and income and premature funeral costs.

(WTP) Willingness to Pay

The maximum amount of money people are willing to pay to obtain or preserve a good, service, benefit or amenity. A market price is a WTP value because it represents the amount people are willing to pay for marketable goods and services.

In Contingency Value surveys, WTP is the amount of money people say they would pay for things or amenities which are not normally bought or sold in markets, and consequently, for which there are no established prices.

APPENDIX B

RECREATIONAL AREA QUESTIONNAIRE

SECTION I - INTERVIEWER COMPLETES

(INTERVIEWER, PLEASE CIRCLE APPROPRIATE AREA CODE AND RECORD NAME OF NEAREST LAKE).

Q.1
1. MUSKOKA/HALIBURTON 1
2. KAWARTHAS 2
3. NORTHERN ONTARIO (North of the French River) 3

Hello, my name is _____ of Applied Research Associates, a consulting and research firm. I'm in this area on behalf of the Ontario Government to talk with people about their use of Ontario's cottage country, about changes in the environment, and about acid rain. When we refer to cottage country, we mean lake areas in Muskoka-Haliburton, Kawartha, Georgian Bay, and Northern Ontario north of the French River.

Q.2 Are you 18 years or over? YES 1
NO (TERMINATE INTERVIEW)..... 2

Q.3 Are you:

AN ONTARIO RESIDENT 1
OTHER CANADIAN 2
A U.S. CITIZEN VISITING CANADA 3
OTHER NON-CANADIAN (SPECIFY) _____(TERMINATE INTERVIEW) 4

Q.4 Are you:

VISITING FOR THE DAY (DO Q.5 AND THEN SKIP TO Q.9) 1
CURRENTLY STAYING OVERNIGHT IN THE AREA 2
PERMANENT RESIDENT OF THE AREA (6 MONTHS OF THE YEAR OR MORE) (SKIP TO Q.6). 3

Q.5 How far is your permanent home from here?

WITHIN 10 MILES 01
11 - 20 MILES 02
21 - 50 MILES 03
51 - 100 MILES 04
101 - 150 MILES 05
151 - 200 MILES 06
201 - 250 MILES 07
251 - 300 MILES 08
300 - 500 MILES 09
MORE THAN 500 MILES (SPECIFY MILES _____) 10

Q.6 Is your accommodation here:

A LAKEFRONT DWELLING 1
AN OFF-LAKE DWELLING 2
CAMPING - LAKEFRONT 3
CAMPING - OFF LAKE 4
HOTEL, MOTEL, CABIN, RESORT - LAKEFRONT 5
HOTEL, MOTEL, CABIN, RESORT - OFF LAKE 6
OTHER (SPECIFY) _____ 7

Q.7 What is the nearest lake to where you are currently staying?

_____

Q.8 Are you:

OWNER 1
PART-OWNER 2
IMMEDIATE FAMILY OF THE OWNER 3
RENTER/OR PAYING GUEST 4
NON-PAYING GUEST 5
OTHER (SPECIFY) _____ 6

SECTION II - RESPONDENT COMPLETES THIS PAGE

(CIRCLE THE NUMBER ON THE RIGHT THAT INDICATES YOUR ANSWER)

Q.9 How much time in total will you likely spend in cottage country during this summer (May to October)? (CIRCLE ONE ANSWER ONLY PLEASE)

NONE	1
LESS THAN 7 DAYS	2
7 - 14 DAYS (ONE TO TWO WEEKS)	3
15 - 21 DAYS (ABOUT THREE WEEKS)	4
22 - 30 DAYS (ABOUT ONE MONTH)	5
31 - 60 DAYS (BETWEEN ONE AND TWO MONTHS)	6
61 - 90 DAYS (2 - 3 MONTHS)	7
90 DAYS OR MORE (BUT NOT A PERMANENT RESIDENT)	8
I AM A PERMANENT RESIDENT HERE	9

Q.10 How much time in total will you likely spend in cottage country during the coming winter (November to April)? (CIRCLE ONE ANSWER ONLY PLEASE)

NONE	1
LESS THAN 7 DAYS	2
7 - 14 DAYS	3
15 - 21 DAYS	4
22 - 30 DAYS	5
30 - 60 DAYS (BETWEEN ONE AND TWO MONTHS)	6
61 - 90 DAYS (2 - 3 MONTHS)	7
90 DAYS OR MORE (BUT NOT A PERMANENT RESIDENT)	8
I AM A PERMANENT RESIDENT HERE	9

Q.11 About how much time in total have you spent in the area right around where we are now, during the last three years? (CIRCLE ONE ANSWER ONLY PLEASE)

NONE	01
LESS THAN 7 DAYS	02
7 - 14 DAYS (1-2 WEEKS)	03
15 - 21 DAYS (2 - 3 WEEKS)	04
22 - 30 DAYS (3 WEEKS TO A MONTH)	05
31 - 60 DAYS (1 - 2 MONTHS)	06
61 - 90 DAYS (2 - 3 MONTHS)	07
91 - 120 DAYS (3 - 4 MONTHS)	08
120 - 180 DAYS (4 - 6 MONTHS)	09
180 - 365 DAYS (HALF YEAR TO A YEAR)	10
MORE THAN ONE YEAR (BUT NOT A PERMANENT RESIDENT)	11
I AM A PERMANENT RESIDENT HERE	12

Q.12 When its the right season for doing the following activities, about what percent of the possible days do you do the following in cottage country?

(PLEASE CIRCLE ONE NUMBER NEXT TO EACH ONE OF THE FOLLOWING ACTIVITIES.)

	No Days	Less than 25% of Possible Days	Between 25% & 50% Possible Days	Between 50% & 75% Possible Days	Almost Every Possible Day
a) FISHING	1	2	3	4	5
b) ROW BOATING	1	2	3	4	5
c) SWIMMING	1	2	3	4	5
d) WATER SKIING	1	2	3	4	5
e) HIKING	1	2	3	4	5
f) SCENIC WALKS	1	2	3	4	5
g) MOTOR BOATING	1	2	3	4	5
h) CANOEING	1	2	3	4	5
i) SAILING	1	2	3	4	5
j) CAMPING	1	2	3	4	5
k) PICNICKING	1	2	3	4	5
l) SCUBA DIVING	1	2	3	4	5
m) HUNTING	1	2	3	4	5
n) OUTDOOR PHOTOGRAPHY	1	2	3	4	5
o) WORK ON A COTTAGE	1	2	3	4	5
p) DRIVE, JUST TO VIEW SCENERY	1	2	3	4	5
q) BICYCLING	1	2	3	4	5
r) WINTER SPORTS	1	2	3	4	5
s) OTHER (SPECIFY)	1	2	3	4	5

SECTION IIA - RESPONDENT COMPLETES THIS PAGE

We want to measure how much importance you place upon the quality of your environment.

Q.13 How important is it to you that fish be protected against any decrease or damage at all from pollution?

EXTREMELY IMPORTANT 1
VERY IMPORTANT 2
IMPORTANT 3
NOT TOO IMPORTANT 4
NOT AT ALL IMPORTANT 5
DON'T KNOW 6

Q.14 How important is it to you that small animals be protected against any decrease or damage at all from pollution?

EXTREMELY IMPORTANT 1
VERY IMPORTANT 2
IMPORTANT 3
NOT TOO IMPORTANT 4
NOT AT ALL IMPORTANT 5
DON'T KNOW 6

Q.15 How important is it to you that water birds be protected against any dercrease or damage at all from pollution?

EXTREMELY IMPORTANT 1
VERY IMPORTANT 2
IMPORTANT 3
NOT TOO IMPORTANT 4
NOT AT ALL IMPORTANT 5
DON'T KNOW 6

Q.16 How important is it to you that water plants and flowers be protected against any decrease or damage at all from pollution?

EXTREMELY IMPORTANT 1
VERY IMPORTANT 2
IMPORTANT 3
NOT TOO IMPORTANT 4
NOT AT ALL IMPORTANT 5
DON'T KNOW 6

Q.17 How important is it to you that land plants and flowers be protected against any decrease or damage at all from pollution?

EXTREMELY IMPORTANT 1
VERY IMPORTANT 2
IMPORTANT 3
NOT TOO IMPORTANT 4
NOT AT ALL IMPORTANT 5
DON'T KNOW 6

SECTION III - INTERVIEWER - (AMENITY VALUES)

(INTERVIEWER - HAND RESPONDENT "ENVIRONMENTAL QUALITY" LADDER.)
Here is a picture of a ladder that shows different levels of pollution in the environment.

Number 10, at the top of the ladder (point to '10' on scale), stands for a clean environment where it is almost totally unpolluted.

Number 1, at the bottom of the ladder (point to '1' on scale), stands for the most polluted environment.

The levels in between (point to numbers 9-2 on scale), stand for general steps from a clean to a polluted environment.

Notice that on the ladder from Level 8 to Level 6, pollution effects mainly fish, and water plants.

From Level 5 and lower, pollution effects not only fish and water plants but also wildlife, birds, trees and plants.

Q.18 Now I'm going to ask you some questions about the value you place on protecting or improving the quality of the environment.

INTERVIEWER: Read only for Visitors from the United States

Pollution is an international problem that effects the environment in the United States and Canada. Protecting or improving the quality of the environment in the United States will likely have a direct influence on the quality of the environment in Canada. Let's assume the Ontario Government could receive some money from the United States to cover costs for protecting and improving the quality of the environment in Ontario. This could result in higher taxes and prices for U.S. citizens.

Let's assume you do not want to pay any more money in taxes per year than you already pay to improve the quality of the environment.

Which of the following areas would you draw money from to cover expenses to protect and improve environmental quality. (Show the respondent the areas; circle number if respondent wants to reduce taxes in the area to cover environmental expenses).

POLICE AND FIRE 1
UNEMPLOYMENT BENEFITS 2
HIGHWAYS 3
HOSPITALS 4
PUBLIC EDUCATION 5
DEFENSE 6
OTHER _____ 7
NONE 8

Now let's assume that you could not take money from other areas even if you wanted to improve environmental quality. In this situation, you would have to pay more in taxes and prices each year to protect or improve the quality of the environment

READ ONLY IF EXPLANATION REQUIRED

That is, part of your taxes to the government is directed to improving environmental quality.

And, part of what we pay in prices for the things we buy covers a company's expenses for improving environmental quality through pollution control.

I have here a scale which indicates how much people pay annually through taxes and prices for various public services. This is to help you decide how much money, if any, you would pay to improve the quality of the environment.

Q.19 First, please indicate which scale represents your total annual household income. (Circle Number)

Below $4,999	01
Between $5,000 - 10,999	02
Between 11,000 - 14,999	03
Between 15,000 - 19,999	04
Between 20,000 - 24,999	05
Between 25,000 - 29,999	06
Between 30,000 - 34,999	07
Between 35,000 - 39,999	08
Between 40,000 - 44,999	09
Between 45,000 - 49,999	10
Between 50,000 - 54,999	11
Between 55,000 - 59,999	12
Above 60,000	13

(HAND PARTICIPANT THE SCALE)

(INTERVIEWER READS THIS)

This is the scale which shows the amount of money someone in your income category pays annually through taxes and prices for various public services. (Point to appropriate column for respondent).

Interviewer: Read only for visitors from the United States

Let's assume that a United States Citizen pays a similar amount of money in taxes and prices for these public services.

You see different amounts of money listed with words next to these money values.

The amounts of money stand for approximately how much money you paid in 1979 in taxes and prices for things like national defense, roads, highways, and education. The other columns stand for approximately what people of other income categories paid in taxes and prices.

READ ONLY IF EXPLANATION REQUIRED
(Point to the number next to highways for the respondents column).

This is approximately what the average size household in your income category paid for the construction and maintenance of the provincial highways.

(Point to the number next to education for the respondents column).
This is approximately what the average household in your income category paid for the public elementary and secondary schools in Ontario.

Using this scale as a rough guide, I would like to ask you some questions about how much, if anything, you would be willing to pay to protect the environment from pollution.

Pollution from a number of sources such as automobile exhaust, power generation, industry and home heating contributes to acid rain. Suppose acid rain could reduce the quality of the environment permanently to a lower level on the ladder. For example,

Let's say the present average for Ontario is level 8 on the ladder. (Point to Level 8). If no more money is spent on pollution control and pollution continues, the environmental quality would soon become worse.

I would like to know how much it is worth to you, if anything, to protect the environment from declining from level 8 to some of the other levels.

Q.20 Let's start by looking at the possibility that the environment could decline from level 8 to level 4. How much, if anything, would you pay in taxes and prices annually to protect the Ontario environment from declining from level 8 to level 4? $_____

Why did you choose this amount? (PROBE)

_____

_____

Q.21 Now, let's look at the possibility that the environment could decline from level 8 to level 7. How much, if anything, would you pay in taxes and prices annually to protect the Ontario environment from declining from level 8 to level 7?

$_____

Why did you choose this amount? (PROBE)

_____

_____

Q.22 Now, how much, if anything, would you pay in taxes and prices annually to protect the Ontario environment from declining from level 8 to level 2?

$_____

Why did you choose this amount? (PROBE)

_____

_____

Q.23 Now, how much, if anything, would you pay in taxes and prices annually to protect the Ontario environment from declining from level 8 to level 6?
$_____

Why did you choose this amount? (PROBE)

_____

_____

Q.24 If more money were spent on controlling pollution and protecting the environment, we could improve the quality from level 8 to level 9. At level 9, the environment is much healthier and cleaner. How much, if anything would you be willing to pay in taxes and prices annually to improve the Ontario environment from level 8 to level 9?

$_____

Why did you choose this amount? (PROBE)

_____

_____

Q.25 Now let's look at the possibility that the environment could improve from level 8 to level 10. How much, if anything would you be willing to pay in taxes and prices annually to improve the Ontario environment from level 8 to level 10?

$_____

Why did you choose this amount? (PROBE)

_____

_____

Q.26 Would you pay more, pay less, or pay about the same as the amounts you said before to protect the environment in Ontario if the changes in it (which we described earlier) were being cause by:

	Pay more	Pay less	Pay about the same
a) OIL AND CHEMICAL WASTE FROM INDUSTRY	1	2	3

PLEASE EXPLAIN (PROBE) _____

_____

_____

b) NATURAL CAUSES (FIRES, FLOODS)	1	2	3

PLEASE EXPLAIN (PROBE) _____

_____

_____

Q.27 What level on the ladder would you consider the quality of the environment to be within a couple of miles of here?

01	02	03	04	05	06	07	08	09	10	DON'T KNOW 99

Q.28 What level on the ladder would you consider the quality of the environment to be in all Ontario?

01	02	03	04	05	06	07	08	09	10	DON'T KNOW 99

SECTION IV - (RESPONDENT COMPLETES THIS SECTION)

(PLEASE CIRCLE THE NUMBER THAT INDICATES YOUR ANSWER)

Q.29 Do you ever fish in the cottage country?

YES 1
NO (GO TO Q.35) 2

Q.30 If you could no longer fish in your usual place in the cottage country (because the lakes had very few fish left in them), would it matter to you?

YES 1
NO 2

Q.31 Where, in the cottage country, (in which lake or river) do you usually fish?

MOST USUAL LAKE OR RIVER: _____
OTHER: _____

Q.32 If you could no longer fish in your usual place in the cottage country, what do you think you would do?

FISH SOMEWHERE ELSE, BUT STILL COME TO COTTAGE COUNTRY 1
FISH SOMEWHERE ELSE AND NOT COME TO COTTAGE COUNTRY 2
NOT FISH SOMEWHERE ELSE, BUT STILL COME TO COTTAGE COUNTRY (GO TO Q.34) 3
NOT FISH SOMEWHERE ELSE, AND NOT COME TO COTTAGE COUNTRY (GO TO Q.35) 4

Q.33 How much further than you travel now would you be prepared to go to find a lake where you could fish?

WITHIN 10 MILES 01
11 - 20 MILES 02
21 - 50 MILES 03
51 - 100 MILES 04
101 - 150 MILES 05
151 - 200 MILES 06
201 - 250 MILES 07
251 - 300 MILES 08
300 - 500 MILES 09
MORE THAN 500 MILES (SPECIFY MILES _____ 10

Q.34 What other things would you do in the cottage country instead of fishing, if there were very few fish?
(CIRCLE UP TO THREE NUMBERS)

ROW BOATING 01
SWIMMING 02
WATER SKIING 03
HIKING 04
SCENIC WALKS 05
MOTOR BOATING 06
CANOEING 07
SAILING 08
CAMPING 09
PICNICKING 10
SCUBA DIVING 11
HUNTING 12
OUTDOOR PHOTOGRAPHY 13
WORK ON A COTTAGE 14
DRIVE JUST TO VIEW THE SCENERY 15
BICYCLING 16
WINTER SPORTS 17
OTHER (SPECIFY) 18
_____ 19
_____ 20

Q.35 Do you ever swim or wade in the cottage country?

YES 1
NO (GO TO Q.41) 2

Q.36 If you could no longer swim or wade in your usual place in the cottage country (because the lake or river water was less suitable for swimmers), would it matter to you?

YES 1
NO 2

Q.37 Where in the cottage country (in which lake or river) do you usually swim?

MOST USUAL LAKE OR RIVER:_____
OTHER _____

Q.38 If you could no longer swim or wade in your usual place what do you think you would do?

SWIM SOMEWHERE ELSE, BUT STILL COME TO COTTAGE COUNTRY 1
SWIM SOMEWHERE ELSE, AND NOT COME TO COTTAGE COUNTRY 2
NOT SWIM SOMEWHERE ELSE, BUT STILL COME TO COTTAGE COUNTRY (GO TO Q.40) 3
NOT SWIM SOMEWHERE ELSE, AND NOT COME TO COTTAGE COUNTRY (GO TO Q.41) 4

Q.39 How much further than you travel now would you be prepared to go to find a lake or river where you could swim?

WITHIN 10 MILES 01
11 - 20 MILES 02
21 - 50 MILES 03
51 - 100 MILES 04
101 - 150 MILES 05
151 - 200 MILES 06
201 - 250 MILES 07
251 - 300 MILES 08
300 - 500 MILES 09
MORE THAN 500 MILES (SPECIFY MILES _____ 10

Q.40 What other things would you do in cottage country instead of swimming? (CIRCLE UP TO THREE RESPONSES)

ROW BOATING 01
FISHING 02
WATER SKIING 03
HIKING 04
SCENIC WALKS 05
MOTOR BOATING 06
CANOEING 07
SAILING 08
CAMPING 09
PICNICKING 10
SCUBA DIVING 11
HUNTING 12
OUTDOOR PHOTOGRAPHY 13
WORK ON A COTTAGE 14
DRIVE JUST TO VIEW THE SCENERY 15
BICYCLING 16
WINTER SPORTS 17
OTHER (SPECIFY) 18
_____ 19
_____ 20

Q.41 What is your personal opinion about each of the following statements?

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree	Don't Know
1. POLLUTION IS A WORLD-WIDE PROBLEM	1	2	3	4	5	6
2. NO SINGLE GOVERNMENT CAN DO MUCH ABOUT POLLUTION	1	2	3	4	5	6
3. PROTECTING THE ENVIRONMENT IS SO IMPORTANT THAT REQUIREMENTS AND STANDARDS CAN NOT BE TOO HIGH	1	2	3	4	5	6
4. THE AVERAGE PERSON CANNOT REALLY DO VERY MUCH TO HELP IMPROVE THE ENVIRONMENT	1	2	3	4	5	6
5. WE MUST RELAX ENVIRONMENTAL STANDARDS IN ORDER TO ACHIEVE ECONOMIC GROWTH	1	2	3	4	5	6
6. I AM MORE CONCERNED ABOUT POLLUTION PROBLEMS NOW THAN I WAS A YEAR AGO	1	2	3	4	5	6
7. AIR AND WATER POLLUTION ARE A RISK TO THE AVERAGE PERSON'S HEALTH	1	2	3	4	5	6
8. WE CAN ACHIEVE OUR CURRENT GOALS OF ENVIRONMENTAL PROTECTION AND ECONOMIC GROWTH AT THE SAME TIME	1	2	3	4	5	6
9. THE ONTARIO GOVERNMENT IS MUCH TOO SOFT ON COMPANIES WHICH POLLUTE	1	2	3	4	5	6
10. INDUSTRIES ARE THE MAIN SOURCE OF AIR AND WATER POLLUTION	1	2	3	4	5	6
11. WE MUST ACCEPT A SLOWER RATE OF ECONOMIC GROWTH IN ORDER TO PROTECT THE ENVIRONMENT	1	2	3	4	5	6
12. PROTECTING THE ENVIRONMENT IS SO IMPORTANT THAT CONTINUING IMPROVEMENTS MUST BE MADE REGARDLESS OF COST	1	2	3	4	5	6

SECTION V - INTERVIEWER TO COMPLETE

Q.42 Have you ever heard of acid rain?

YES 1
NO 2

Q.43 How much of a problem, do you think acid rain is?

A VERY SERIOUS PROBLEM 1
A SMALL PROBLEM 2
NOT A PROBLEM 3
NO OPINION 4

Q.44 To your knowledge, what happens to the environment when it rains acid rain?

(PROBE...ACCEPT MORE THAN ONE RESPONSE...ANSWER MUST BE AT LEAST TEN WORDS).

_____

_____

_____

Q.45 How serious is pollution from each of these sources in Ontario's cottage country? (CIRCLE APPROPRIATE NUMBER).

	Not a Problem	A Small Problem	A Serious Problem	Don't Know
a) WATER POLLUTION FROM SEWAGE	1	2	3	4
b) HAZARDOUS WASTE DISPOSAL	1	2	3	4
c) OIL AND CHEMICAL WASTES FROM INDUSTRY	1	2	3	4
d) NOISE	1	2	3	4
e) ACID RAIN	1	2	3	4
f) GARBAGE DISPOSAL	1	2	3	4
g) NUCLEAR POWER PLANT		2	3	4
h) OTHER (SPECIFY) _____ ...	1	2	3	4

SECTION VI - RESPONDENT TO COMPLETE

Q.46 Your sex:

1. MALE 1
2. FEMALE 2

Q.47 Your age:

18 - 19 YEARS 01
20 - 24 YEARS 02
25 - 29 YEARS 03
30 - 34 YEARS 04
35 - 39 YEARS 05
40 - 44 YEARS 06
45 - 49 YEARS 07
50 - 54 YEARS 08
55 - 59 YEARS 09
60 - 64 YEARS 10
65 - 69 YEARS 11
70 OR OLDER 12

Q.48 Which of the following best describes your present permanent residence?

DETACHED HOME 1
SEMI-DETACHED HOME 2
DUPLEX/TOWNHOUSE OR ROW HOUSE 3
HI-RISE APARTMENT (OVER 4 FLOORS) 4
LOW-RISE APARTMENT 5
OTHER (SPECIFY) _____ 6

Q.49 Do you rent or do you own this permanent residence?

RENT 1
OWN 2
OTHER (SPECIFY) _____ 3

Q.50 Are you now:

MARRIED 1
SINGLE (NEVER MARRIED) 2
DIVORCED 3
SEPARATED 4
WIDOWED 5
OTHER (SPECIFY) _____ 6

Q.51 How many people 18 years or older (including yourself) live as part of your family in your permanent home?

Number _____

Q.52 How many children 17 years or younger live as part of your family in your permanent home?

Number _____

Q.53 What is the last grade of school you have completed?

PUBLIC/ELEMENTARY SCHOOL (GRADE 1-8) 1
SOME HIGH SCHOOL 2
GRADUATED HIGH SCHOOL (GRADE 12 or 13) 3
VOCATIONAL/TECHNICAL/COLLEGE 4
SOME UNIVERSITY 5
GRADUATED UNIVERSITY 6

Q.54 Are you employed (for pay) at the present time?

EMPLOYED FULL-TIME (35 HOURS PER WEEK OR MORE) (GO TO Q.46) 1
EMPLOYED PART-TIME 2
UNEMPLOYED - LOOKING FOR FULL-TIME WORK 3
NOT EMPLOYED - NOT LOOKING FOR FULL-TIME WORK 4

Q.55 If you are not employed for pay full-time, are you in one or more of the following groups?

RETIRED 1
HOMEMAKER 2
STUDENT 3
ILL, OR DISABLED 4
OTHER 5

Q.56 In two words or more, what is your present occupation? (Skip if not presently employed).

_____

Q.57 In two words or more, what is your husband's/wife's occupation? (Skip if spouse is not presently employed).

_____

(FOR COTTAGE OWNERS)

Q.58 What do you estimate to be the current fair market value of your cottage real estate?

ESTIMATE $_____